WATER–RESOURCES INVESTIGATIONS IN TENNESSEE: PROGRAMS AND ACTIVITIES OF THE U.S. GEOLOGICAL SURVEY, 1987-1988

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PROGRAMS AND ACTIVITIES OF THE U.S. GEOLOGICAL SURVEY, 1987-1988

by Ferdinand Quinones, Barbara H. Balthrop, and E.G. Baker

U.S. GEOLOGICAL SURVEY

Open-File Report 88-322

Nashville, Tennessee
1988

DEPARTMENT OF THE INTERIOR

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A MESSAGE FROM THE TENNESSEE DISTRICT CHIEF:

This report summarizes the principal programs and activities of the Water Resources Division of the U.S. Geological Survey in Tennessee during the last 12 months. It has been an exciting period of many varied activities, projects, and investigations. The variety of these activities is a reflection of the complexity of the water issues in Tennessee and points out the need for a strong ongoing water-resources research program. The USGS is in a position to meet this challenge with an outstanding staff, necessary resources, and pertinent programs in partnership with other county, state, and federal agencies that participate in the District cooperative programs.

During the last year, we have witnessed a significant shift in the orientation of the projects and investigations we conduct. Ground water has emerged as one of the most important environmental issues in the Nation and the State. In Tennessee, ground water provides about 51 percent of the drinking-water supplies, and its use is increasing at a faster rate than surface-water supplies. Several communities, including Memphis and Jackson, depend entirely on ground water as their source of drinking water. There are significant concerns among the people and government officials about the quality, quantity, and ocurrence of ground water in Tennessee. The USGS is meeting these concerns through assigning higher priorities and additional funds to investigations involving ground-water issues. In the years to come, this trend will continue.

The mission of the USGS in Tennessee is to provide timely, accurate, and unbiased water-resources information to citizens and government officials. We intend to continue meeting the goals of this mission by maintaining excellence in our staff and programs. We feel proud of the accomplishments of the last year. I wish to share these successes with the cooperating agencies and organizations that have made these programs possible.

Ferdinand Quinones
District Chief, WRD
Tennessee District

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HYDROLOGIC DATA SECTION

Hydrologic data, or basic data as it is commonly named, is the backbone of the investigations conducted by the U.S. Geological Survey (USGS). The basic data programs conducted by the Tennessee District provide streamflow, quality of water, and ground-water levels information essential to the assessment and management of the State's water resources. Long-term streamflow, quality of water, and ground-water levels networks are operated as part of the Hydrologic Data Section. Field operations are about equally divided among field offices in Memphis, Nashville, and Knoxville. A staff of about 40 engineers, hydrologists, and hydrologic technicians labor in the operation of the long-term network as well as short-term efforts in support of areal investigations. The data collected as part of the networks are published in the series of annual data reports entitled "Water Resources Data for Tennessee." Engineer Jeff May is the chief of the Hydrologic Data Section, assisted by engineers W. Harry Doyle in Memphis, Delmer O'Connell in Nashville, and Bob Livesay in Knoxville, chiefs of those respective subdistricts.

Hydrologic Data Section personnel.

SURFACE-WATER MONITORING NETWORK

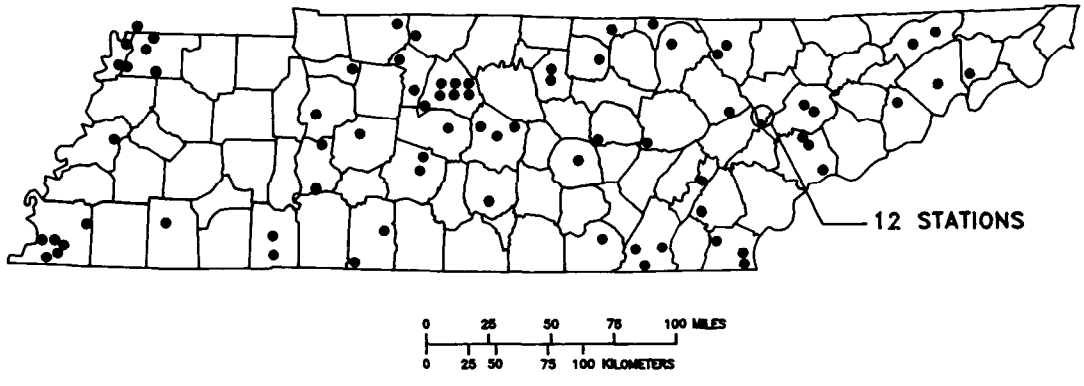
The Tennessee District operates a network of continuous streamflow gaging stations throughout Tennessee. In 1988, the network includes 85 continuous streamflow gages and 12 continuous stream or lake water-level only gages. Additionally, 22 continuous rainfall stations were operated in conjunction with other research or lake-level gages. Continuous streamflow data are recorded and disseminated for many purposes, including:

- Assessment of water available for many and variable uses.
- Operation of impoundment and pumping structures.
- Flood or drought monitoring and forecasting.
- Waste disposal and control.
- Legal requirements and enforcement.
- Research and hydrologic trends or other special studies.

Changes to this network in 1988 include adding 5 stations and discontinuing 22 stations.

Program cooperators supporting this network are:

Tennessee Valley Authority (TVA)
U.S. Army Corps of Engineers, Nashville District (COE)
Tennessee Department of Health and Environment (TDHE)
Tennessee Wildlife Resources Agency (TWRA)
Cities of: Alcoa, Bartlett, Lawrenceburg, Memphis,
Metropolitan Government of Nashville
and Davidson County, and Murfreesboro.
U.S. Department of Energy (DOE)
Shelby County
Memphis Light, Gas and Water (MLGW)

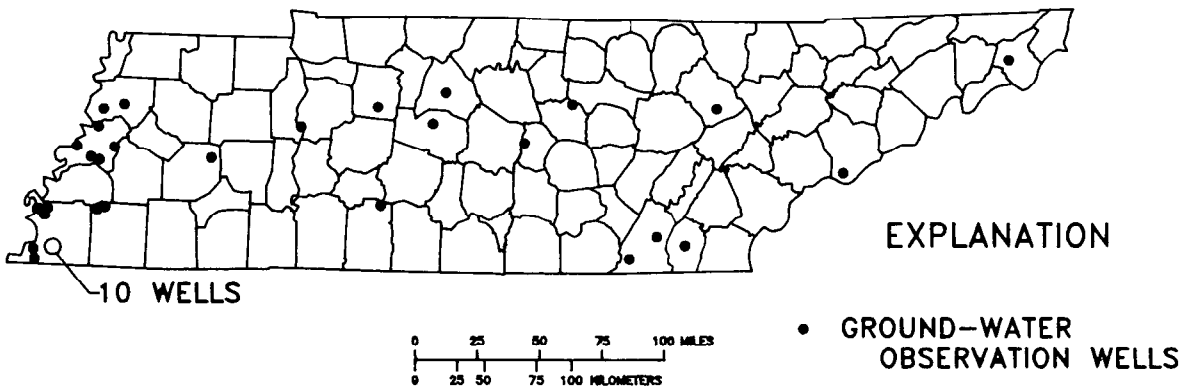


Location of streamflow stations in Tennessee.

GROUND-WATER LEVEL NETWORK

The USGS operates about 30 observation wells in cooperation with the Office of Water Management, Tennessee Division of Health and Environment and about 18 observation wells in cooperation with Memphis Light, Gas, and Water. The 30 observation wells are part of the Statewide ground-water-level network. These wells are used to monitor water-level fluctuations in response to natural and man-induced stress on the ground-water system.

The observation wells in the Memphis area monitor the water-level response to pumping from the major well fields in the Memphis area. The Memphis Sand aquifer currently supplies about 196 million gallons of water per day for municipal and industrial supplies in the Memphis area. Memphis Light, Gas and Water is the single largest user of ground water in the State.

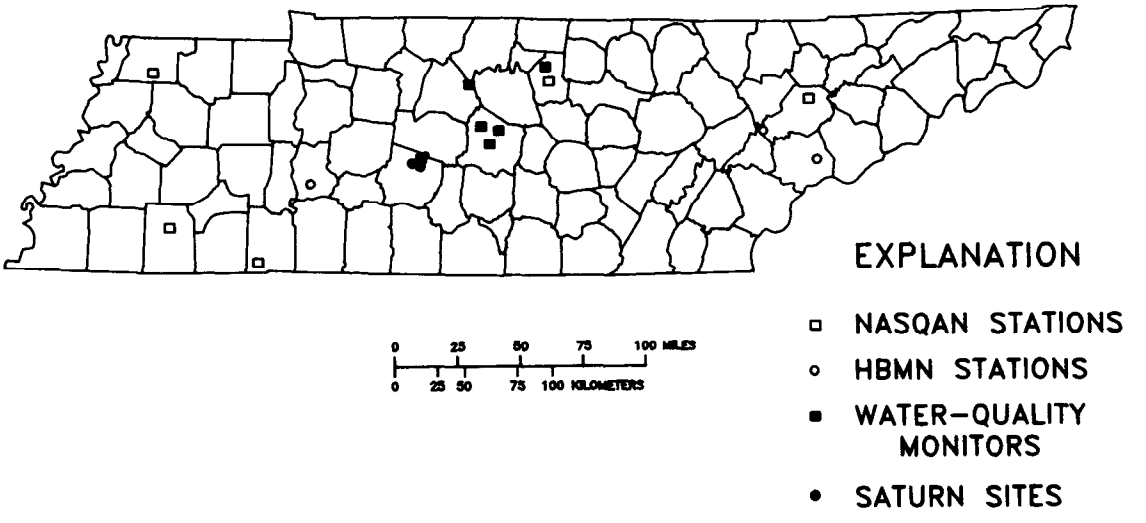


Location of observation wells in Tennessee.

WATER-QUALITY NETWORK

The USGS monitors water quality at numerous surface-water stations in Tennessee. Six stations compose part of the National Stream Quality Accounting Network (NASQAN). NASQAN data-collection sites are located at or near the downstream end of hydrologic accounting units. A comprehensive list of physical and chemical characteristics are measured bimonthly or quarterly to fulfill information needs of water-resources planners and managers. Two sites within the State are part of the national Hydrologic Bench-Mark Network (HBMN). At HBMN sites the USGS assesses natural streamflow and water quality of small river basins that are known to be relatively little affected by man's activities. In cooperation with the U.S. Army Corps of Engineers, water-quality monitors are operated at four sites along the Cumberland River and its tributaries in Middle Tennessee. A fifth monitor is located above the wastewater treatment plant for the city of Murfreesboro. These instruments record hourly values for water temperature and conductance, and, in some cases, pH and dissolved-oxygen concentration. Water quality also is assessed quarterly at three sites in Maury County near the new Saturn industrial facility. At these sites concentrations of suspended sediments, bacteria, organic compounds, and priority pollutant metals are determined.

The USGS is actively pursuing plans for a statewide network to monitor the quality of ground water. This network will consist of approximately 200 wells chosen to represent the State's principal aquifers and land-use patterns.

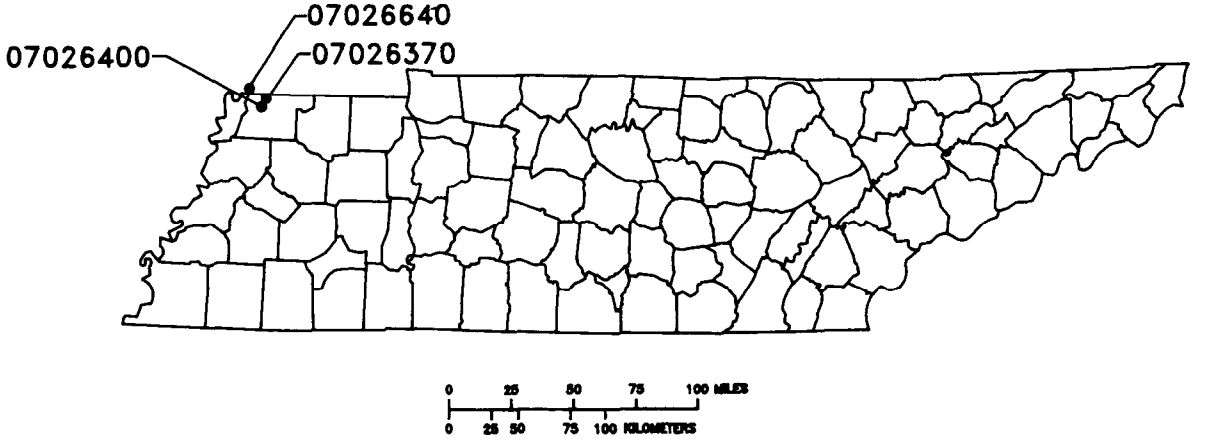


Water-quality data-collection sites in Tennessee.

SUSPENDED-SEDIMENT NETWORK

In cooperation with the Tennessee Wildlife Resources Agency (TWRA), the USGS conducts sediment transport investigations in Tennessee. The program provides sediment data to define sediment loads, concentrations, and transport characteristics for Tennessee streams. The data are also used to define the effects of impoundments on transport characteristics, to define long-term trends, and to provide a data bank for programs in water management and monitoring.

Three daily-record stations in the Reelfoot Lake drainage basin (North Reelfoot Creek at State Highway 22, near Clayton, Tenn.; South Reelfoot Creek near Clayton, Tenn.; and Running Slough near Ledford, Ky.) were in operation in 1987-88. The purpose of these stations is to monitor the suspended-sediment discharge into Reelfoot Lake. Hydrologist Bill Carey is in charge of the sediment programs.



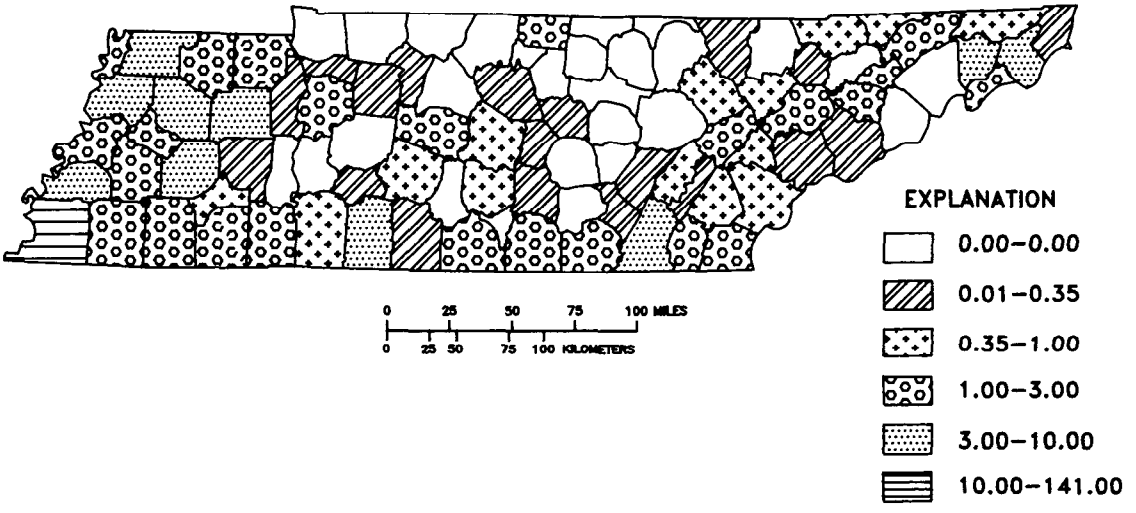
Location of sediment stations in Tennessee.

WATER-USE PROGRAM

Collecting water-use data is one of the most important basic data programs conducted by the USGS. In cooperation with the Tennessee Department of Health and Environment, the USGS water-use program has the following objectives:

- Determine how much fresh surface and ground water is withdrawn and for what purposes; how much water is consumed during use; and, how much water is returned to the source after use.
- Develop and refine a computerized system to store and retrieve the water-use information.
- Devise and apply techniques and methods to improve the analysis of water-use data.
- Prepare and publish reports about water use in Tennessee and its importance as part of the hydrologic cycle.

During 1987, water-use data were collected for the categories agriculture, industry, public supply, hydroelectric and thermoelectric power generation. Reports were prepared describing: the use of water in Tennessee in 1985; groundwater public-supply sites; an inventory of irrigation; and, an inventory of public-supply withdrawals. Hydrologist Susan Hutson, from the Memphis Subdistrict office, directs the Tennessee Water-Use Information Program.



Ground-water public-supply withdrawals, in million gallons per day, by county in 1987.

FLOOD INVESTIGATIONS

In cooperation with the Tennessee Department of Transportation (TDOT) and the Metropolitan Government of Nashville and Davidson County, the USGS is conducting flood investigations in Tennessee. The objective of this program is to appraise and define the flood characteristics of Tennessee streams by:

- Investigation and documentation of outstanding floods.
- Operation of a network of about 90 crest-stage partial-record gages to provide flood data on small streams and in parts of the state where data are sparse.
- Providing analytical techniques and reports as needed to further understand the flood hydrology of Tennessee.

Other aspects of the program provide for preparation of hydraulic analyses at specific sites and verification of hydraulic techniques. The site analyses can be simple or complex, depending on the site and type of data needed by TDOT. At almost all sites, data on historical floods is required. Additional data requirements may be as simple as a stage-discharge relation at the site for the unconstricted valley. Complex sites where the roadway may parallel a stream may require flood-profile computations for a long reach of stream, and could include computation of flow through several bridges or culverts.

Several analytical reports, in addition to reports documenting outstanding floods, have been published to aid the cooperator in the proper design of hydraulic structures within the State's highway system. Included within those reports were the following:

- Method to compute depth of floods of various recurrence intervals at ungaged sites.
- Method to compute a flood hydrograph for most ungaged sites within the state.
- Regionalized flood-frequency analyses to provide peak discharges for ungaged sites for various recurrence intervals.

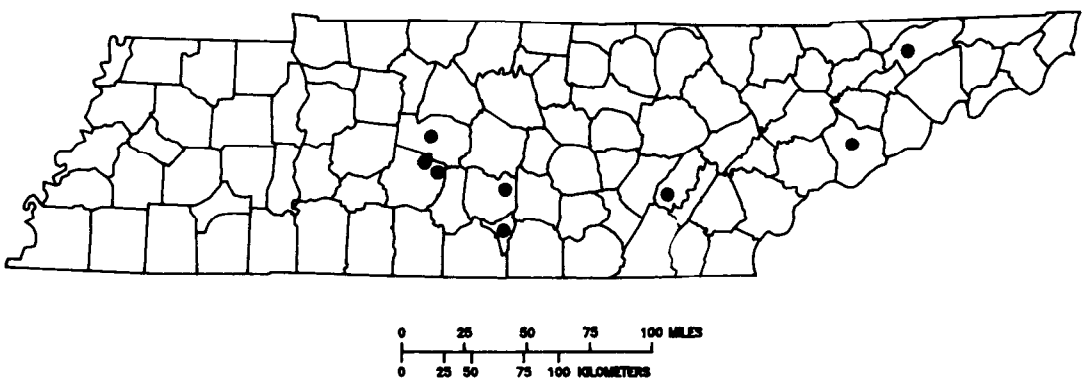
During the 1987 fiscal year, numerous requests were answered from the TDOT for miscellaneous flood and other hydrologic information. The areal extent of this project is statewide and the project chief is hydrologist Charles Gamble.

HYDROGRAPH CONTROLLED RELEASE STREAMFLOW GAGES

At some locations, the State of Tennessee will issue effluent release permits to wastewater treatment facilities to release treated effluence to a receiving stream in proportion to the flow of the stream. That type of release system is referred to as a Hydrograph Controlled Release (HCR) system. Two primary components of a HCR system are storage capacity for treated effluence at the treatment plant, such as lagoons, and a streamflow gaging station on the receiving stream.

From the continuous recorders at the gaging station, an electronic signal giving the rate of flow in the receiving stream is transmitted to the treatment plant control center or to any office that needs the data for plant operations. The signal can be transmitted over landlines (telephone or dedicated lines) or by radio transmitter from a data collection platform (DCP) in the gaging station instrument house to a GOES satellite. The GOES satellite will relay the signal back to a ground receive antenna and from that location it is sent over telephone lines to the USGS's Nashville computer center, or any computer center nationwide. If remotely transmitted streamflow data are not needed for plant operations but periodic or daily readings are needed, an observer can read the gage instruments to determine the streamflow at any time. The gaging station is usually located close to the wastewater treatment plant, therefore, it does not require a lot of time to stop and read the gage.

Eight HCR gages are in various stages of completion, from being fully operational to negotiations and planning, in Middle and East Tennessee. The USGS will match up to 50 percent of all construction, instrumentation, and operational costs along with 50 percent provided by State or local governmental agencies for these HCR gages. Continuous streamflow data from the gages are archived permanently on the USGS's Nashville computer system, published annually, and used in other hydrologic investigations of water resources in the stream basins.

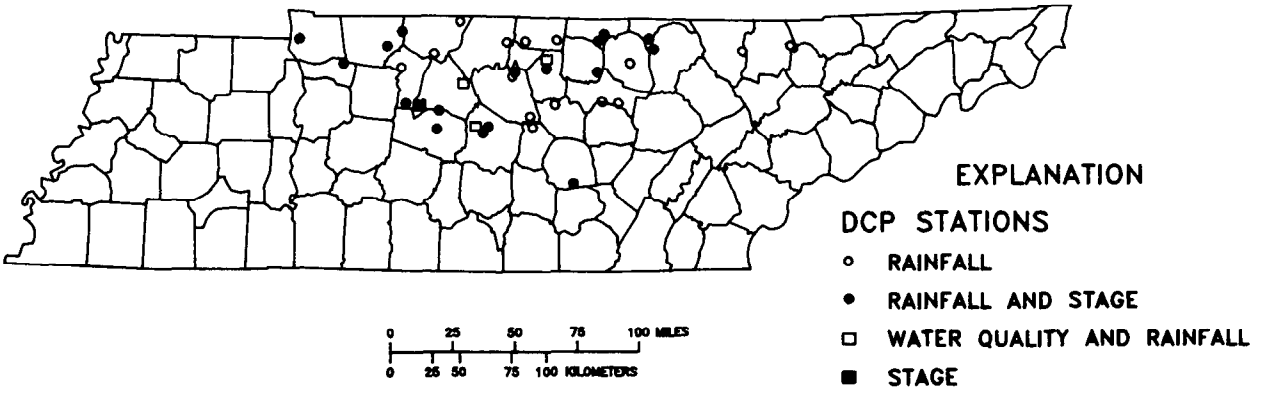


Location of HCR streamflow gages.

DCP NETWORK

In cooperation with the U.S. Army Corps of Engineers, Nashville District (COE), the USGS is operating a network of real-time stations that monitors streamflows, water-quality, and rainfall in the Cumberland River basin. The network includes 36 stations equipped with data collection platforms (DCP) that transmit data to a GOES stationary orbiting satellite. The program provides quality control to assure that accurate data is being collected; and review of those data on a daily basis provides information for efficient scheduling of field crews to make streamflow measurements, service the recorders and perform maintenance. The COE utilizes the data for the management and operation of the Cumberland River system. Data from the network is especially important for real-time response to major floods in the basin.

Automatic recording instruments collect streamflow water-quality and precipitation data. The information is transmitted by the DCP at 2-hour intervals. The data is received by ground stations at the facilities in Columbia, South Carolina, and the COE offices in Cincinnati, Ohio. The ground stations transmit the data to computers at the USGS and COE offices in Nashville, Tennessee. Graphic and table outputs permit a continuous scan of current precipitation and streamflow parameters from the DCP output. The data are archived and published in the annual data reports.



Network of DCP stations.

HYDROLOGIC INVESTIGATIONS SECTION

The Hydrologic Investigations Section of the Tennessee District, WRD, is responsible for the design and execution of interpretive areal water-resources investigations. Surface-, ground-, and quality-of-water studies throughout the State are conducted in support of federal and cooperative programs. Projects, ranging in duration from 1 to 14 years, include areas as large as 45,000 square miles, and can cost as much as several million dollars.

The staff of the Hydrologic Investigations Section includes about 20 highly qualified and experienced geologists, engineers, biologists, and technicians. The high caliber of the staff is reflected in the number of scientists with doctoral degrees (4), master degrees (9), and other advanced college work. Experienced hydrologists and technicians are supported by a strong staff of recently hired engineers and scientists. State-of-the-art equipment is utilized in complex hydrological investigations.

In 1987, the Hydrologic Investigations Section was involved in 14 areal studies. Four projects were completed and four were initiated. The Section staff produced more than 32 reports, journal papers, and symposia articles.

Hydrologic Investigations Section personnel.

STABILITY OF SELECTED CHANNEL REACHES IN WEST TENNESSEE

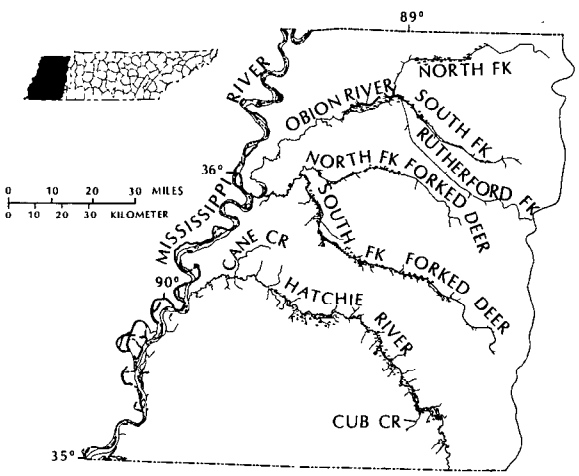
In cooperation with the Tennessee Department of Transportation (TDOT), the USGS has conducted investigations of channel-stability characteristics as part of TDOT's program of bridge designs. Like the bridge-site reports that delineate hydraulic and hydrologic characteristics of specific sites, these studies are designed to address questions concerning channel bed and bank stability. The majority of the sites investigated from year to year are located in West Tennessee where channel instability is a significant problem.

From six to eight site studies are done each year and usually consist of various combinations of the following tasks:

- Channel surveys.
- Review of available data (such as hydrologic, construction plans).
- Bed- and bank-material sampling.
- Shear-strength testing.
- Slope-stability analysis.
- Bed response analysis.
- Dendrochronologic analysis of riparian vegetation.
- Analysis of rates of bank widening or accretion.

This is a continuing study that benefits both TDOT and the USGS by supplying a means of acquiring channel information on streams other than those included in the larger channel evolution studies. It also allows for continuing technology transfer between the USGS and the TDOT.

Most channel reaches encountered during this study are, to some extent, unstable. Bank conditions are assessed through slope-stability analyses and then tested for various alignments and water-table heights. Factors of safety for these various conditions are then reported to TDOT as part of the site-study report. Andrew Simon, geomorphologist, is the project chief.



Location of study streams in West Tennessee.

HYDROGEOLOGY OF RADIOACTIVE WASTES BURIAL GROUNDS AT THE OAK RIDGE NATIONAL LABORATORY

The ground-water and surface-water flow systems near the radioactive waste burial grounds at the Oak Ridge National Laboratory are being investigated in cooperation with the U.S. Department of Energy. Low-level radioactive wastes have been buried in shallow trenches on the laboratory grounds since 1944, and most wastes are buried in Melton Valley. Radionuclides have leached from the wastes and have been transported by ground water away from burial areas to local streams in the valley. The project began in 1975 and will be completed in 1989.

The objectives of the study are to provide:

- Descriptions of the ground-water and surface-water flow systems near the waste burial grounds.
- Descriptions of the quality of ground water and surface water near the burial areas.
- Hydrologic information for development of an integrated ground-water and surface-water monitoring system.

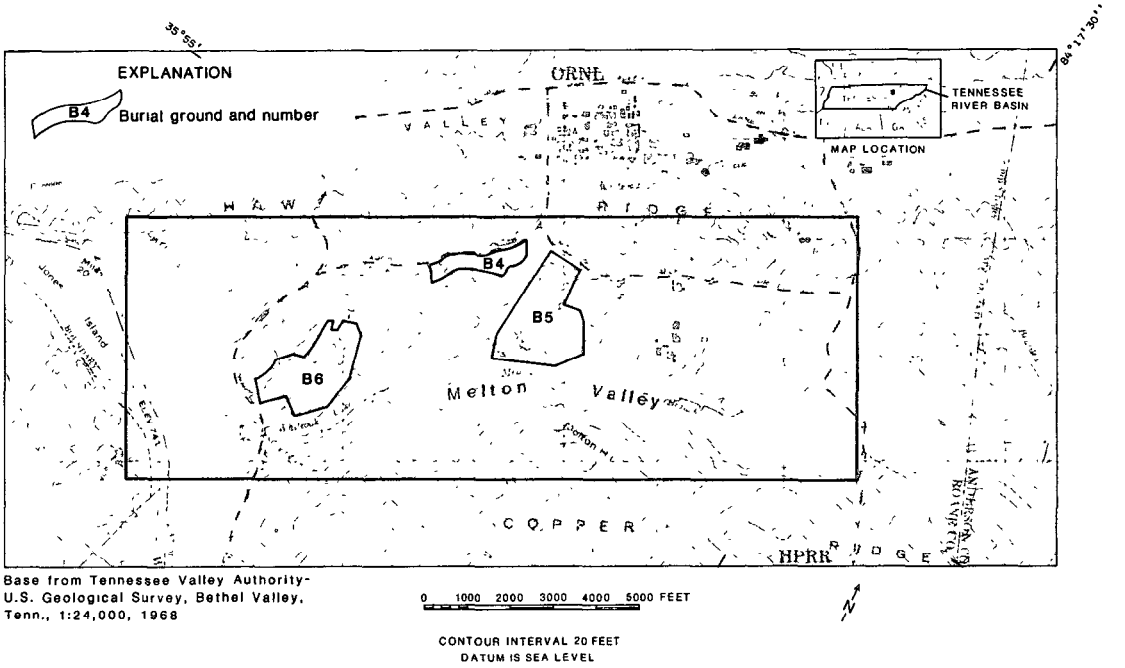
Data and interpretive information will be provided for use in remedial-action investigations presently underway at Oak Ridge National Laboratory.

Several types of data are being collected in order to provide a base for understanding the flow systems:

- Surface-water data are being collected at the two principal streams draining the burial areas.
- Several surface-geophysical methods were used to provide information on subsurface stratigraphy and structure. Fifteen auger holes and 9 shallow wells were installed to determine depth to bedrock and to provide information on flow through the maximum 60-foot thick weathered rock strata in Melton Valley. Nine two-well clusters and one three-well cluster were recently completed to a maximum depth of 230 feet.
- Geologic, water-level, and water-quality data are being collected from the wells to provide information on ground-water boundaries, flow through both shallow weathered rock and deeper bedrock, and water quality within the flow system.

Conceptual flow through the ground-water system was described in a report completed in early 1988. A three-dimensional model of ground-water flow is presently being developed. A report describing preliminary modeling results has been published.

Data collection, flow-model development, and data interpretation will continue through 1988. Work in 1989 will consist of writing a hydrogeologic report based on all data collected during the span of the project. The project leader is Harold Zehner, a geologist in the Knoxville Subdistrict office.



Study area and location of burial grounds.

HYDROGEOLOGY OF THE McNAIRY-NACATOCH AQUIFER IN WEST TENNESSEE

In 1983, the Tennessee District of the USGS began a 6-year investigation of the deep regional aquifer systems of the northern Mississippi embayment. This investigation is part of a National program of regional aquifer-systems analyses (RASA), and this particular study focuses on the McNairy-Nacatoch and contiguous aquifers of West Tennessee and adjacent states.

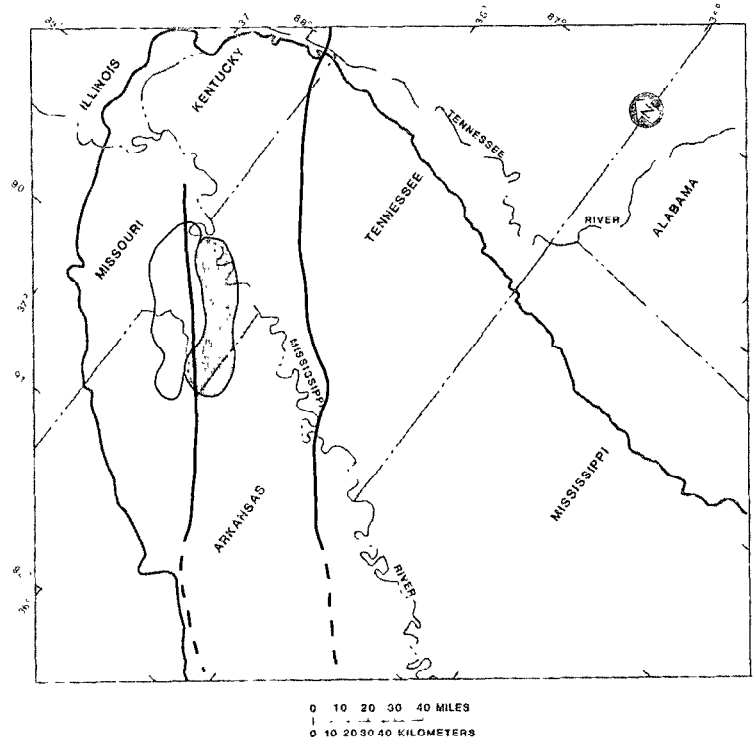
Results from the investigation are providing project chief Dr. John Van Brahana with valuable insight into the complex flow system:

- Flow-modeling studies indicate that the aquifer can safely support more than twice the current pumping rate.
- Geochemical and thermal modeling studies indicate that water from this aquifer can provide heat for small-scale, local uses in a limited area in southeast Missouri.
- Newly developed age-dating techniques suggest that water from this aquifer is very old (from 30,000 to more than a million years). Isolation from near-surface contamination makes this aquifer an ideal alternative water-supply system in the event shallower aquifers become contaminated.

Major accomplishments include publication of:

- Flow-modeling results.
- Documentation of the model.
- Extensive water-quality data collected specifically for this study.

New research techniques being used in this study hold promise for widespread application to hydrologic problems in other areas of similar hydrogeology.



Zone of abnormally warm water in McNairy-Nacatoch aquifer.

HYDROGEOLOGY IN THE VICINITY OF THE Y-12 PLANT AT THE OAK RIDGE RESERVATION

Several hazardous-waste disposal sites where contaminants may be leaching into ground and surface water are located in Bear Creek Valley, within the Oak Ridge Reservation. An investigation of Bear Creek Valley and Union Valley, an extension of the valley to the east, is being conducted in cooperation with the U.S. Department of Energy. The objectives of the investigation of the hydrogeology of the valley are to:

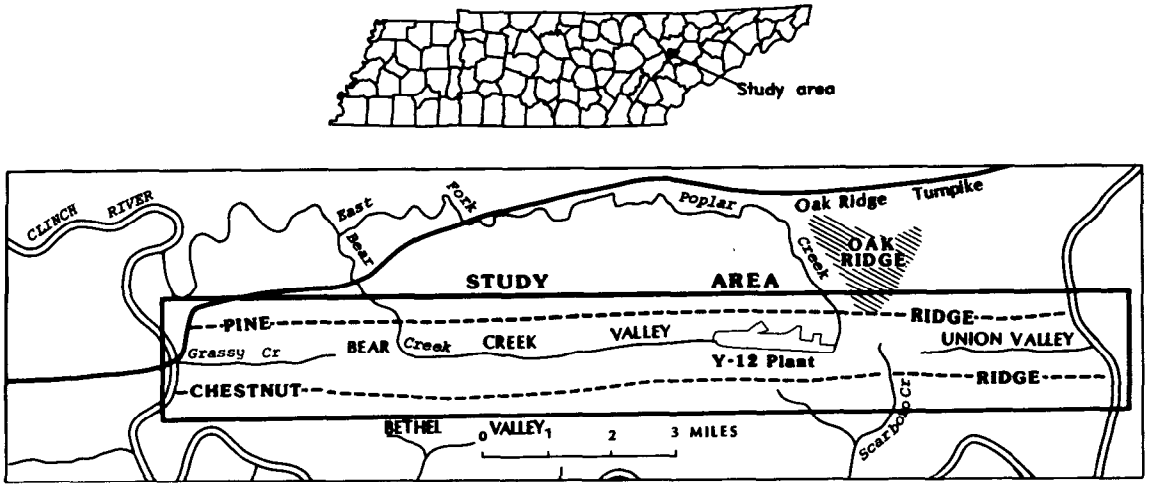
- Formulate an understanding of the ground-water flow system.
- Determine the potential extent of contaminant migration.

Initial phases of the project, begun in 1984, included:

- Assessment of existing geologic and hydrologic data.
- Collection of surface-water flow and water-quality data.
- Installation of well clusters on the hydrologic boundaries of the valley.
- Mapping formations within the Conasauga Group.
- Interpreting geochemistry data.
- Analyzing hydraulic-conductivity data by statistical and regression-model techniques.
- Formulating a concept of the flow system.

Four data reports and two interpretive reports have been published.

During 1987, a three-dimensional ground-water flow model was constructed using the concepts and hydraulic characteristics determined during earlier phases of the project. Three interpretive reports have been approved for publication. A final project report will summarize the hydrogeologic findings of the study and present the results of the ground-water flow modeling and geochemical analyses. The project is directed by Zelda Bailey (geologist) assisted by Roger Lee (geochemist) and Dr. Joseph Connell (engineer).



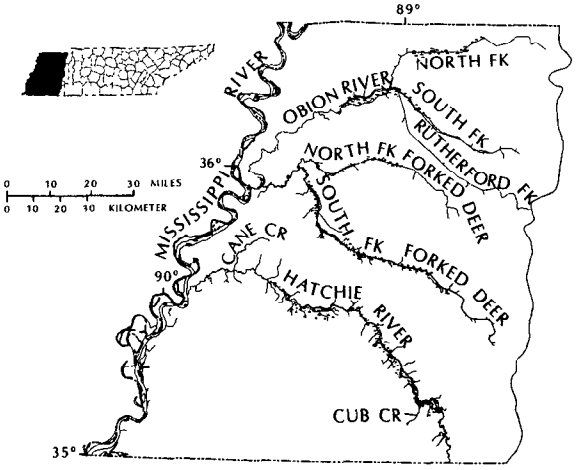
Location of Bear Creek Valley study area.

CHANNEL EVOLUTION INVESTIGATIONS IN WEST TENNESSEE STREAMS

Channel modifications throughout much of West Tennessee's alluvial streams have caused large-scale channel adjustments such as upstream degradation, downstream aggradation, and bank failures. As a result of these adjustments, a number of highway bridges have collapsed, in some cases, leading to the loss of life. The primary objective of this study, conducted in cooperation with the Tennessee Department of Transportation, is to quantitatively assess ongoing and future channel changes through the development of empirical models of alluvial-channel evolution.

Results have shown that degradation occurs for 10 to 15 years at a site, followed by an equal period but lesser amount of aggradation. Reaches close to the area of maximum disturbance are the most severely affected with the magnitude of the response decreasing with distance upstream. Changes on the channel bed are closely tied to subsequent changes of the channel banks and, together, have been organized into a six-stage model of channel evolution. Bank widening does not occur until degradation and fluvial undercutting of the banks has heightened and steepened the channel banks beyond their critical conditions. Bank-failure thresholds and rates of channel widening are assessed through shear-strength testing, field surveys, and dendrochronology.

The majority of the channels are still unstable. Those that have been redredged recently, such as the South Fork Forked Deer River, will remain unstable for a long time to come. The project staff, headed by Andrew Simon (geomorphologist) with the assistance of Dr. Cliff Hupp (botanist) and Bradley Bryan (hydrologist), is now completing quantitative descriptions of channel changes such as widening, timing to initial bank stability, critical conditions of bank stability, and hydraulic characteristics of each stage of the model. These subroutines of the model will be combined into an empirical model of channel evolution over time and space. The project was completed at the end of 1987.



Location of study streams in West Tennessee.

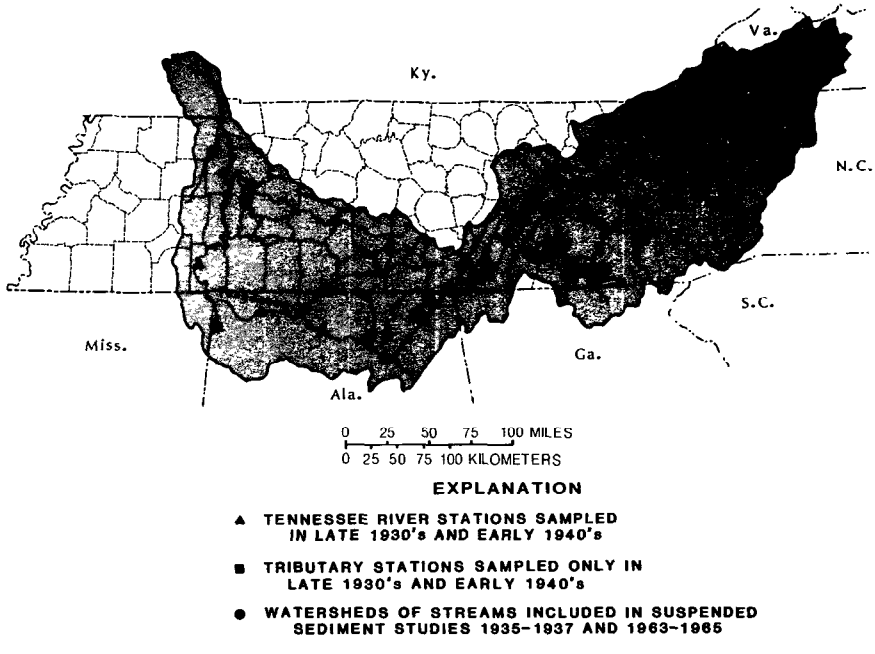
SEDIMENT YIELDS IN THE TENNESSEE RIVER BASIN, 1930-60

Historical records of suspended-sediment data in the Tennessee and Cumberland River basins are being compiled as part of a project in cooperation with Tennessee Technological University. The primary objective of the project is to compile and enter into computer storage suspended-sediment data that were collected by the Tennessee Valley Authority during sampling efforts in the late 1930's and mid-1960's. These data consist of daily record for 48 stations obtained during the 1930's and daily record for 10 stations obtained during the 1960's. A second objective is to use the data to assess the sediment transport characteristics and yields of the basins sampled.

A draft version of a master index to sediment data in the Tennessee and Cumberland River basins has been prepared. The index consists of a table for each basin that lists information about available data for each station. These tables will be included in a report that discusses the history of sediment sampling in the two basins and describes the available data. A report of the data inventory has been prepared and will be available soon.

Tennessee Technological University has created daily value files of concentration data for 52 stations. These files are currently being read into and stored on the USGS WATSTORE data storage system. Statistical analyses have been completed and the final report is in review.

The project is headed by Bill Carey, hydrologist, with the assistance of Dr. Russ T. Brown from Tennessee Technological University.



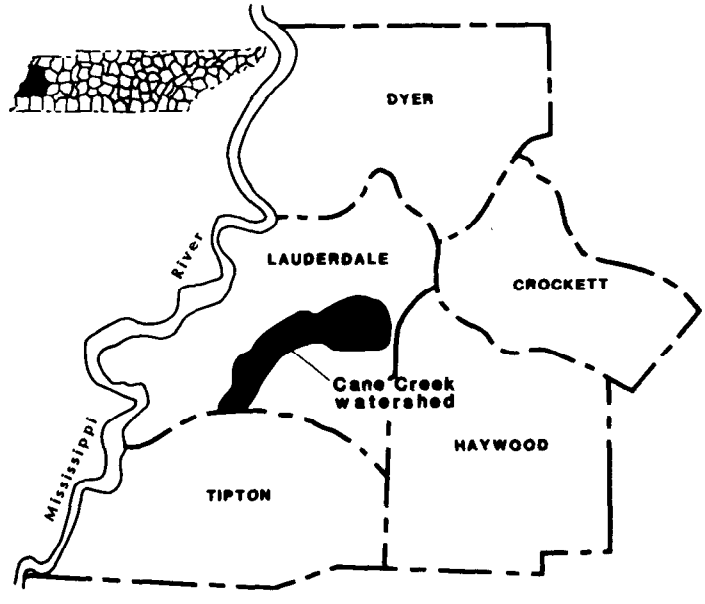
Location of suspended-sediment stations in the Tennessee River basin.

GEOMORPHIC CHANGES IN THE CHANNEL OF CANE CREEK IN WEST TENNESSEE

In cooperation with the U.S. Soil Conservation Service, the USGS is conducting a study to determine the present state of channel morphology, to estimate future channel changes due to natural adjustment processes, and to evaluate alternative measures for regaining stable channel conditions. Assessment of channel adjustment trends and estimation of future channel geometry will provide the information needed to protect bridges, farmland, and ultimately human life.

Postmodification downcutting and widening of the Cane Creek main channel was found to have basinwide effects. Main channel evolution resulted in tributary system downcutting and widening. Tributary system degradation has lagged behind the main channel because of lower flow capacities. Because of the erosive nature of the Cane Creek basin soils, tributary system degradation is expected to continue until the level of the main channel is reached.

Evaluation of Cane Creek channel adjustment trends and future channel geometry have provided a basis for determining appropriate engineering applications for controlling degradation. The project, led by both Andrew Simon (geomorphologist) and Bradley Bryan (hydrologist), is scheduled for completion in April 1988.



Location of Cane Creek in Lauderdale County, West Tennessee.

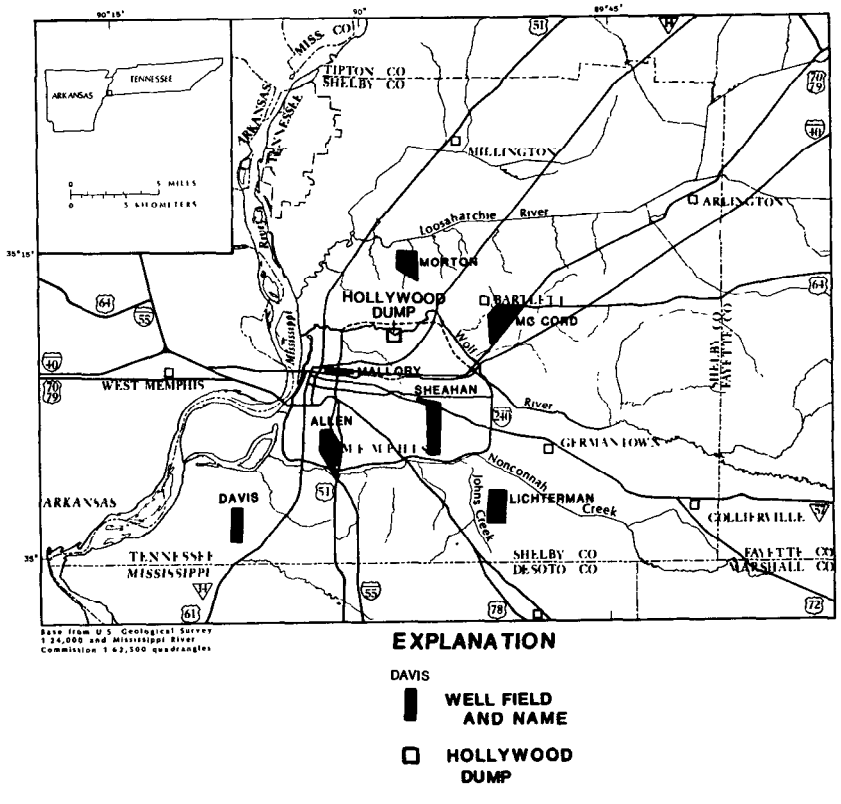
PESTICIDE TRANSPORT AT NORTH HOLLYWOOD DUMP, MEMPHIS, TENNESSEE

The USGS, in cooperation with the City of Memphis, is conducting a hazardous-waste study at the North Hollywood Dump, a municipal-industrial landfill which is on the U.S. Environmental Protection Agency's "Superfund" list. The City of Memphis is particularly concerned with the possible contamination of its drinking-water aquifer by cancer-causing chemicals. Residues of pesticides have been detected in local soils, sediments, biota, and in ground and surface waters. The goals of the study are to:

- Describe the current extent of contamination at the site.
- Estimate the potential for migration of toxic constituents toward points of human exposure.

Water-quality sampling efforts at 50 monitoring wells have outlined a diffuse plume extending from the dump downgradient toward the Wolf River. The highest concentrations of organochlorine pesticides were 37 micrograms per liter (μg/L) of lindane and 24 μg/L of chlordane. Analyses for specific conductance, chloride, and total organic carbon supported the concept that leachate introduced to the surficial aquifer remains in the shallow flow system and discharges directly to the Wolf River.

Two reports describing the results and conclusions of the study will be completed by the end of 1988. Co-project chiefs are hydrologist Mike Bradley and Dr. Robert Broshears.



Hollywood Dump and Mempis Light, Gas and Water municipal well fields.

EVIDENCE OF VERTICAL LEAKAGE TO THE MEMPHIS SAND AQUIFER NEAR THE SHELBY COUNTY LANDFILL, MEMPHIS, TENNESSEE

Ground water from the alluvial aquifer near the Shelby County landfill is leaking vertically to the underlying Memphis Sand aquifer. The objectives of this investigation were to:

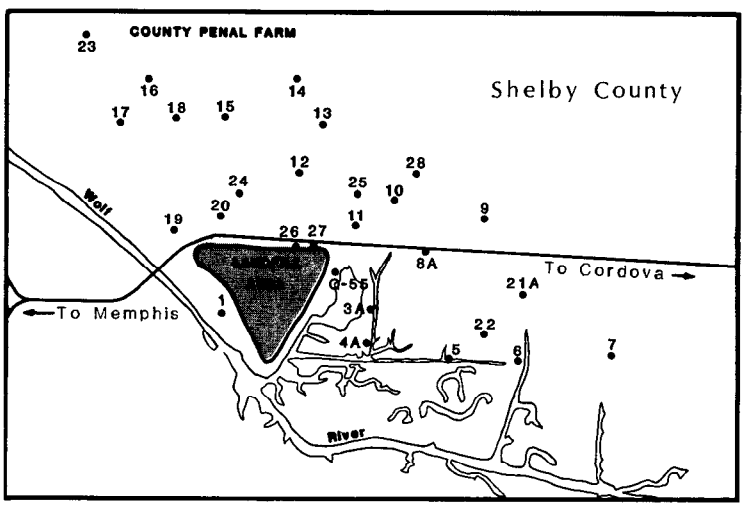
- Determine the extent of leakage to the Memphis Sand aquifer.
- Determine if contamination from the landfill has migrated to the alluvial aquifer and possibly to the Memphis Sand aquifer. This study was conducted in cooperation with the Shelby County Department of Public Works and the Tennessee Department of Health and Environment, Division of Solid Waste Management.

Water-quality analyses from the alluvial and Memphis Sand aquifers were compared to determine the effect of leakage into the Memphis Sand. Ground water in the alluvial aquifer contains 100 to 300 milligrams per liter (mg/L) dissolved-solids concentrations. In areas affected by leachate migration, the dissolved-solids concentrations are 700 to 1,000 mg/L. Ground water in the Memphis Sand aquifer in the area near the Shelby County landfill generally contains 50 to 80 mg/L dissolved solids, 2 to 5 mg/L chloride, and 23 to 74 mg/L hardness as calcium carbonate. In the area of vertical leakage, the water quality of the Memphis Sand aquifer has been affected by water from the alluvial aquifer and dissolved-solids concentrations are about 150 mg/L; chloride concentrations about 5 to 20 mg/L; and hardness about 80 mg/L. There is no evidence of contamination from the landfill reaching the Memphis Sand aquifer at this site.

With the movement of water from the alluvial aquifer into the Memphis Sand aquifer, tritium concentrations in water from the Memphis Sand should show the presence of recent water. Tritium concentrations in ground water can be used to identify water that has entered the water table since about 1953. Atmospheric testing of nuclear weapons in the early 1950's effectively 'tagged' recent precipitation with elevated tritium concentrations. Water in the alluvial and terrace aquifers in the Memphis area have tritium concentrations of 4 to 9 tritium units (TU). The tritium concentration of water from the Memphis Sand in areas without significant leakage is generally less than 2 TU. The Memphis Sand aquifer in the area near the Shelby County landfill contains water with tritium concentrations ranging from less than 1 to about 10 TU. The vertical distribution of tritium units in ground water near the landfill is:

- 10 TU in the alluvial aquifer.
- 5 to 10 TU in the shallow Memphis Sand.
- less than 1 TU in the middle Memphis Sand aquifer.

The project leader for the investigation, which ended in September 1987, was Michael Bradley, hydrologist.



Shelby County landfill area and location of well sites.

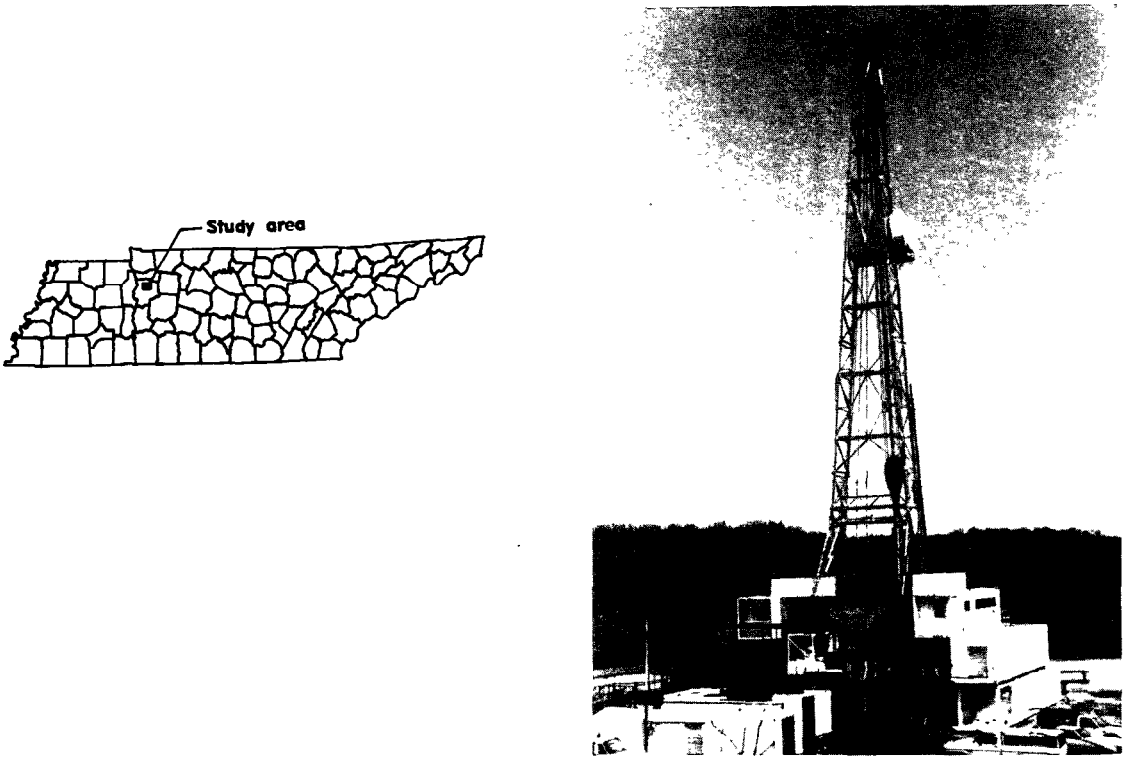
STRATIGRAPHY AND HYDROGEOLOGY AT A DEEP TEST WELL, HUMPHREYS COUNTY

One of the deepest wells in the United States with a continuous core and comprehensive hydrologic tests is being drilled by DuPont de Nemours Co., Inc., in Humphreys County, Tennessee. The well will be drilled to a depth of 8,500 feet below land surface. Four-inch core samples will be collected from land surface to the bottom of the well. Approximately 24 hydrologic tests will be conducted by the USGS in cooperation with Humphreys County to determine the hydrology of each aquifer and confining layer present at the site.

Hydrologic tests will include:

- Determination of aquifer yields.
- Determination of the presence of confining beds.
- Collection of water-quality samples.

The water-quality analyses will include a full suite of major and trace inorganic constituents, dissolved gases, isotopes, and age determinations. Tritium, carbon-14, and chloride-36 will be used to determine the age of the water samples. The project chief of the investigation is Michael Bradley. The project, which began in January 1988, is scheduled for completion in September 1990.



Location of Humphreys County study area and drill site.

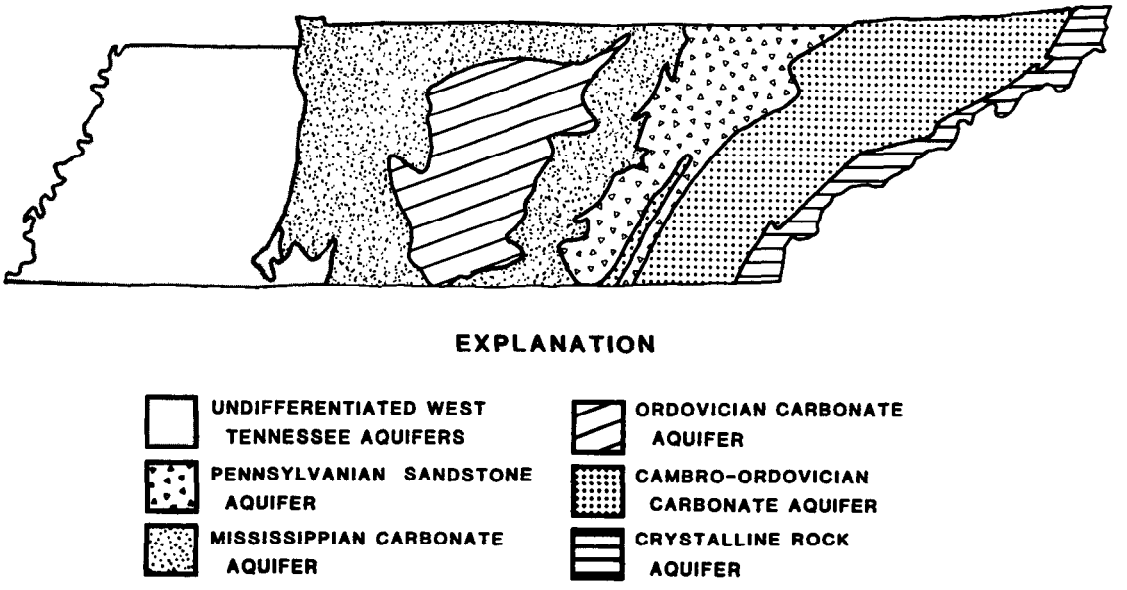
INVESTIGATION OF RECHARGE AND HYDRAULIC CHARACTERISTICS OF AQUIFERS IN TENNESSEE UTILIZING BASE FLOW OF STREAMS

In cooperation with the Division of Groundwater Protection of the Tennessee Department of Health and Environment, the USGS is conducting an investigation to assess recharge and hydraulic characteristics of selected unconfined aquifers in Middle and East Tennessee. Quantification of the hydrologic and hydraulic properties of these aquifers is essential for development of ground water in this area, where demand for water is increasing. The initial phase of the project, begun in 1985, included base-flow analysis of streamflow hydrographs from 75 drainage basins to determine values for:

- Recharge rate to the aquifer.
- Aquifer hydraulic diffusivity.
- Transmissivity.
- Storage coefficient.

These estimates have already found application in several hydrogeologic investigations, including digital groundwater flow modeling studies, currently conducted by the Tennessee District.

Accomplishments during 1987 included statistical analyses of these estimates to determine regional trends and correlation among variables and preparation of a draft version of a final report for the project. This report summarizes the analytical methods used in the investigation and presents the estimates and statistical analyses of recharge rate and hydraulic characteristics. The project is scheduled for completion in 1989. Project leader is Anne Hoos, engineer.



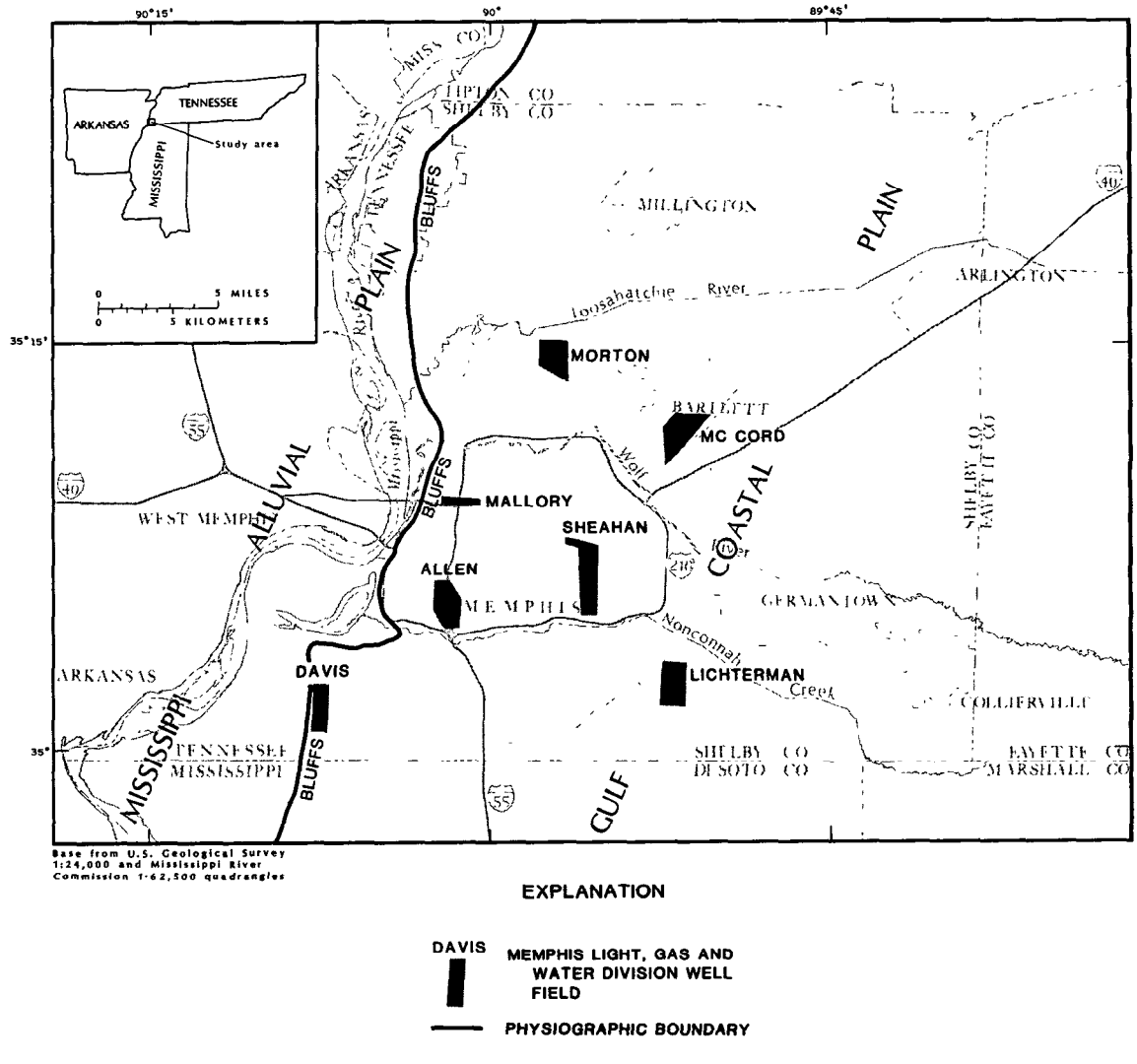
Major unconfined aquifers in Tennessee.

PRELIMINARY ASSESSMENT OF THE POTENTIAL FOR CONTAMINATION OF THE MEMPHIS SAND AQUIFER IN THE MEMPHIS AREA, TENNESSEE

The City of Memphis and most of Shelby County depends entirely on the Memphis Sand aquifer for water supply. Traditionally, the Memphis Sand has been thought of as an ideal artesian aquifer overlain by a thick, impermeable clay bed that serves as the upper confining layer and protects the aquifer from contamination from near-surface sources. Studies, however, have shown that the confining layer locally is thin or absent, or it contains sand "windows" that could provide "pathways" for contaminants to reach the Memphis Sand aquifer. Studies also have shown that downward leakage occurs from the water-table aquifers (alluvium and fluvial deposits) to the Memphis Sand aquifer.

Recently, synthetic organic compounds have been detected in two municipal supply wells in the Memphis Sand aquifer--one at Collierville and the other in the Allen well field of Memphis Light, Gas and Water Division at Memphis. These are the first instances of synthetic organic compounds having been detected in the Memphis Sand aquifer and prove that the principal aquifer in the Memphis area is vulnerable to contamination. Thousands of potential sources of contamination exist in the Memphis-Shelby County area. These sources include:

- Abandoned and active solid waste disposal sites.
- Underground storage tanks containing synthetic organic compounds.
- Industries and commercial establishments using or processing hazardous materials.



Location of project area and Memphis Light, Gas and Water Division well fields.

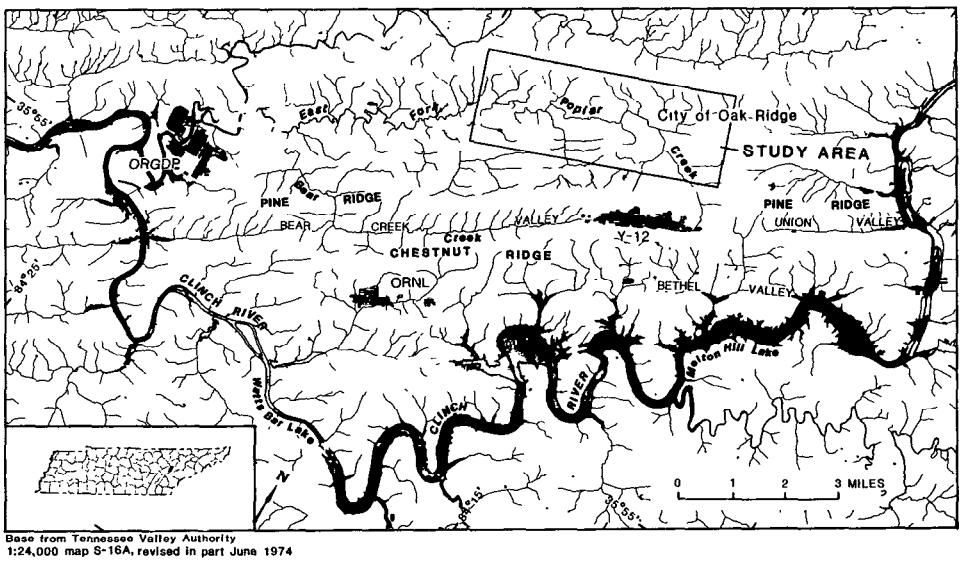
Many of these potential sources of contamination are in proximity to municipal and industrial well fields, which contain about 200 wells. The extent and degree of any contamination of the Memphis Sand aquifer from these po-tential sources of contamination is not known.

The objective of the present investigation (conducted in cooperation with the City of Memphis, Memphis Light, Gas and Water Division and the Tennessee De-partment of Health and Environment, Division of Solid Waste Management) is to make a preliminary assessment of the potential for contam- ination of the Memphis Sand aquifer in the Memphis area by identifying potential sources of contamination and showing their location as related to direction of ground-water flow and thickness of the confining layer separating the water-table aquifers from the Memphis Sand aquifer. William S. Parks, (geologist) in the USGS Memphis Subdistrict office, is the project leader.

GROUND-WATER QUALITY IN THE SHALLOW AQUIFER NEAR EAST FORK POPLAR CREEK AT OAK RIDGE

In cooperation with the U.S. Department of Energy, the USGS recently completed a study of ground-water contamination in the shallow aquifer system in and near the flood plain of East Fork Poplar Creek, near the Oak Ridge Reservation. Water-quality samples collected from 17 USGS monitor wells in April 1987 were analyzed for selected organic compounds by International Technology Corporation in Knoxville, and for selected trace metals, miscellaneous organic substances, and radionuclides by the K-25 Plant Analytical Chemistry Department, in Oak Ridge.

Although unfiltered samples from several of the wells contained antimony, chromium, lead, mercury, selenium, total phenols, and radioactivity from strontium-90 in concentrations which exceeded drinking-water standards, samples filtered for dissolved analyses contained only uranium in elevated concentrations. These data indicate that most contaminants in the unfiltered samples were associated with sediment which was removed from the dissolved samples by filtration, and therefore, represent concentrations which are significantly higher than those actually occurring in the ground water. A report summarizing the results of the completed study is being prepared by the project leader, hydrologist John Carmichael.

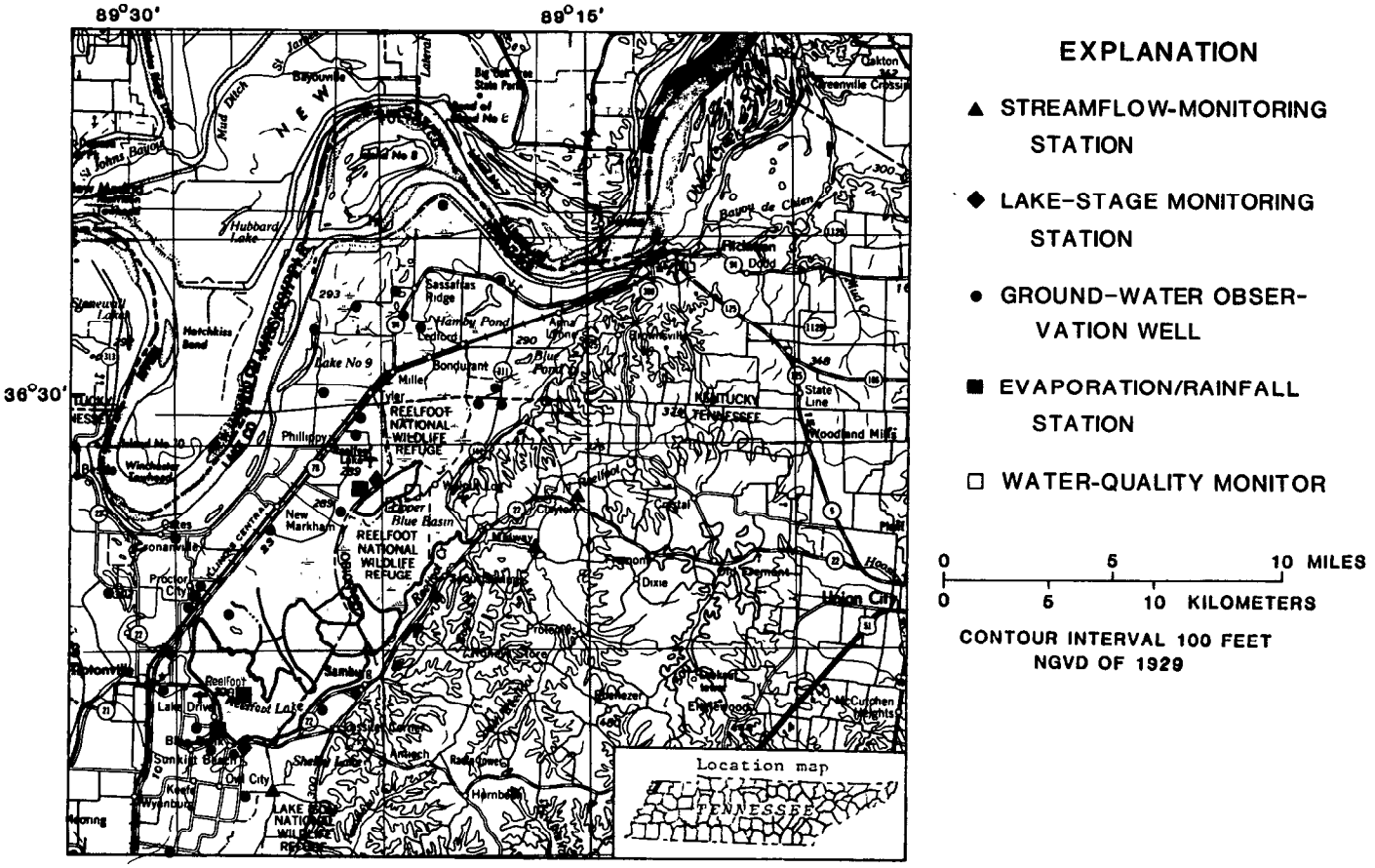


Base from Tennessee Valley Authority
1:24,000 map S-16A, revised in part June 1974

Location of East Fork Poplar Creek study area.

EFFECTS OF PROPOSED DIVERSION ON REELFOOT LAKE IN WEST TENNESSEE

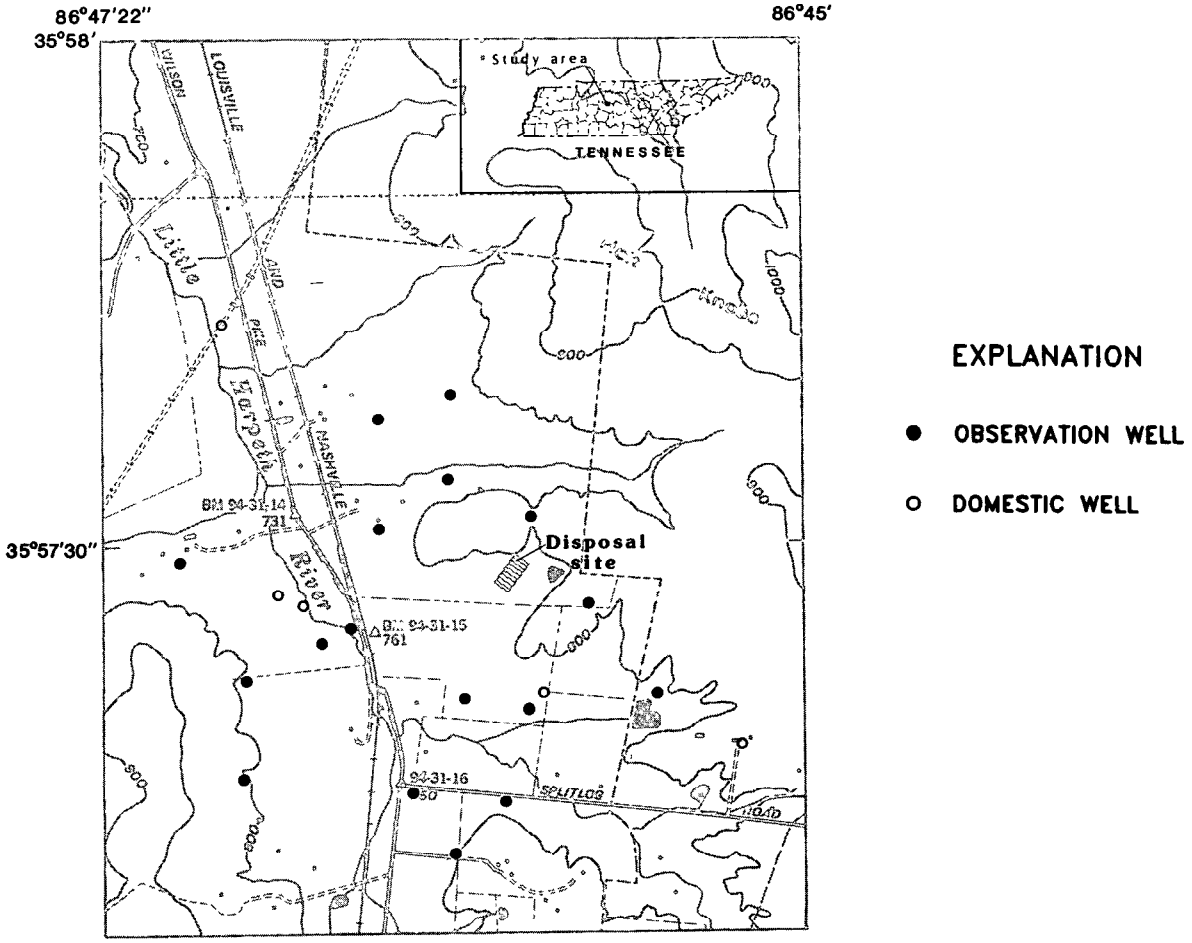
Reelfoot Lake, in northwestern Tennessee, is a valuable natural resource that is threatened by sedimentation, eutrophication, and deterioration of the quality of the water. An investigation was begun by the USGS in 1986, in cooperation with the Tennessee Wildlife Resources Agency (TWRA), to quantitatively define the hydrology of the Reelfoot Lake basin, and to determine the impacts of various management strategies. This information is needed to evaluate available water supplies to the lake and the potential environmental impacts of lake-level manipulation and pumpage. The objectives will be accomplished by analyses of data from extensive climatic, surface-water, and ground-water data-collection networks using energy budget and mass-transfer equations, calibrated streamflow synthesis models, and finite-difference ground-water flow models. Data collection was completed in March 1988, and the final report is in preparation. Hydrologist Mike Lewis is the project chief.



Location of project area, Reelfoot Lake, and data-collection stations.

INVESTIGATION OF GROUND-WATER CONTAMINATION FROM A HAZARDOUS-WASTE DISPOSAL SITE NEAR BRENTWOOD, WILLIAMSON COUNTY

In cooperation with the Division of Superfund of the Tennessee Department of Health and Environment, the USGS is in the final stages of a comprehensive 2-year investigation of ground-water contamination near Brentwood, Tennessee. Project activities have included: (1) drilling and monitoring of water levels in 34 wells at 17 sites near the disposal site, (2) two seepage investigations to provide information on ground-water contribution to the Little Harpeth River, (3)borehole and surface geophysics, (4) computer simulation of ground-water flow, and (5) water-quality analyses. Additionally, soil-gas sampling techniques were tested to aid in the delineation of the contaminant plume. Results of the investigation indicate that the upper aquifer, in which the waste was disposed, is effectively isolated from the lower aquifer by the Hermitage confining unit. Three reports on the results of the study will be published in 1988: (1) "Construction, geologic, and water-level data for observation wells near Brentwood, Williamson County, Tennessee," (2) "Lithology and geologic structure of a hazardous-waste disposal site in Williamson County, Tennessee", and (3) "Hydrogeology of a hazardous-waste disposal site near Brentwood, Williamson County, Tennessee." The investigation is directed by Roger Lee (geochemist), with the assistance of Patrick Tucci (modeling specialist) and Dorothea Withington (geologist).

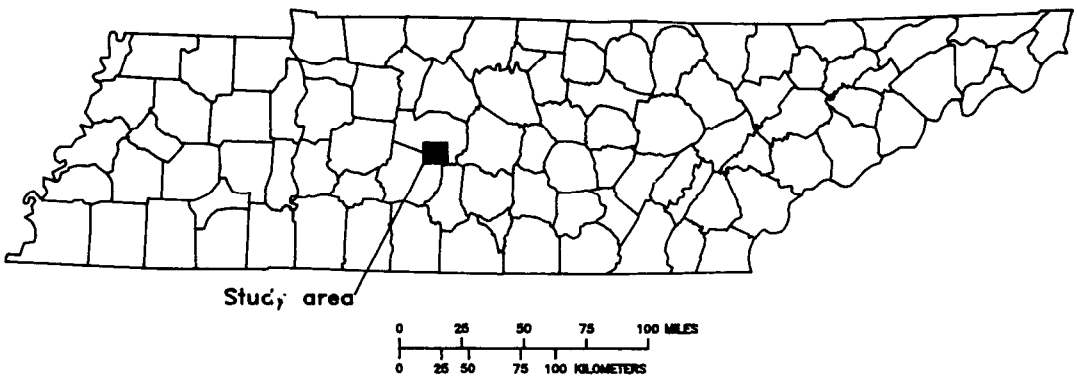


Location of Brentwood, Williamson County, study area.

GROUND-WATER AVAILABILITY IN THE SPRING HILL AREA, MAURY AND WILLIAMSON COUNTIES

In cooperation with the City of Spring Hill, in April 1987, the USGS made a study of the discharge of ground water to streams in a 50-square-mile area around Spring Hill. The streams at the time were discharging on the average of 400 gallons per minute (gal/min) for each square mile of drainage area. Several of the 45 basin segments yielded considerably more water than the average and, on this basis, three sites were picked for drilling test wells.

Spring Hill used this information to drill two test wells yielding about 10 and 40 gal/min each. In addition, they tested an existing well at one of the three sites, pumping at a maximum rate of 286 gal/min for 3-$^{1}/_{2}$ hours with only 54 feet of drawdown. The Nashville Subdistrict Office, under the direction of Delmer O'Connell, made the streamflow measurements that were interpreted by E.F. Hollyday, hydrogeologist and project chief.



Location of Spring Hill study area in Tennessee.

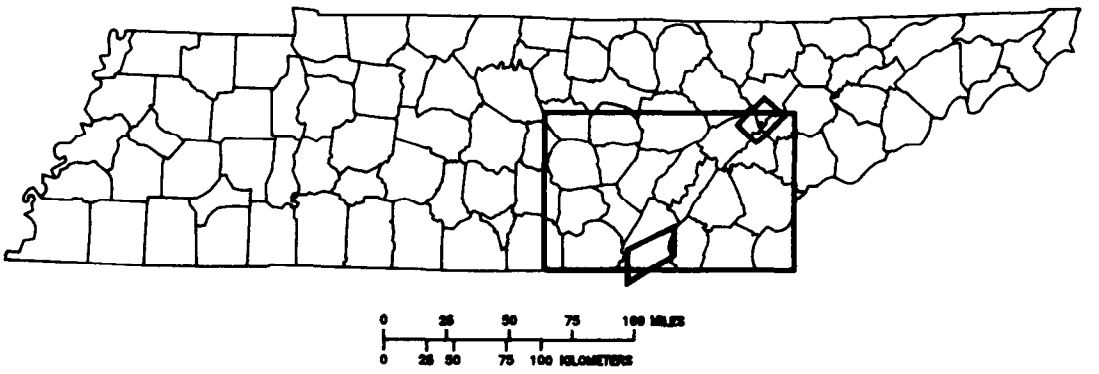
SIDE-LOOKING AIRBORNE RADAR DATA FOR USE IN ESTIMATING SUSCEPTIBILITY FOR GROUND-WATER CONTAMINATION

The objective of this project is to test the usefulness of side-looking airborne radar for mapping ground-water pollution susceptibility in the Valley and Ridge physiographic province in East Tennessee.

The investigation involved an evaluation of the pollution susceptibility of the Valley and Ridge province in an area including and surrounding the city of Oak Ridge. The DRASTIC system for evaluating pollution potential as developed for the U.S. Environmental Protection Agency was used. Three hydrogeologic settings were designated and the pollution potential, referred to as the DRASTIC index, of each was computed.

In areas where the boundaries of the hydrogeologic settings were compared to the map boundaries produced from overlays, a very good match of the boundary lines occurred over most of the area. This close correlation enabled the hydrogeologic settings and the corresponding DRASTIC indexes to be transferred from the Oak Ridge radar image to the Chattanooga 2° quadrangle. A DRASTIC index was computed for a landfill site on the Chattanooga quadrangle for comparison with the transferred index. It was found that radar images can be used successfully in conjunction with a methodology such as DRASTIC to evaluate ground-water pollution susceptibility.

The project was supported from federal funds from the USGS headquarters in Reston, Va. A report is being prepared by hydrogeologist E.F. Hollyday and geologist Dolores Mulderink.



Location of radar test site in East Tennessee showing the 2° quadrangle covered by a radar mosaic and two smaller sites covered by digital radar data.

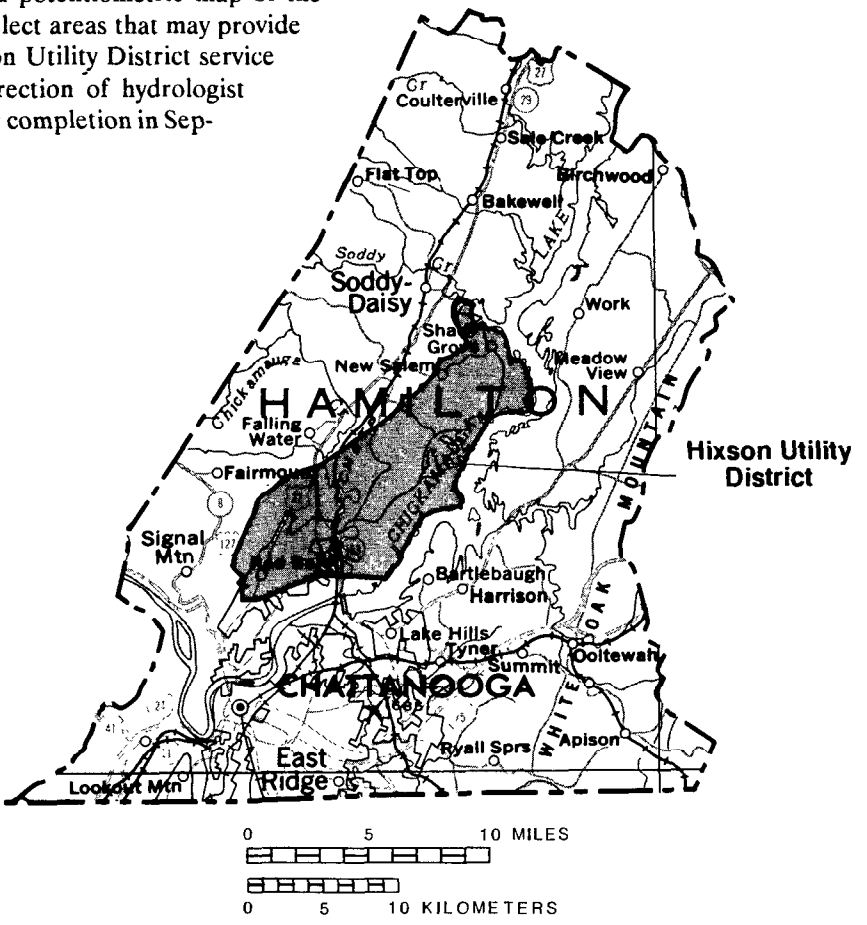
WATER-SUPPLY POTENTIAL OF THE GROUND-WATER SYSTEM OF THE HIXSON UTILITY DISTRICT OF HAMILTON COUNTY

In cooperation with the Hixson Utility District, the USGS is conducting an appraisal of the availability of ground-water in the Hixson Utility District service area. Objectives are to:

- Define the geology and ground-water hydrology of the service area.
- Define the areal extent and storage capacity of the Cave Springs reservoir.
- Identify and test areas where there is greatest protential for additional development of ground-water supply.
- Characterize the existing water quality and its variability with recharge events of the Cave Springs reservoir.
- Assess the vulnerability of the Cave Springs reservoir to contamination from surface sources.

The utility district currently withdraws water from an extensive cave system in the limestones of Cave Springs Ridge. Aquifer tests using the large-capacity pumps operated by the utility district indicated a specific capacity of 2,800 gallons per minute per foot of drawdown. Additional drilling near the existing wells revealed more solution openings below the major cave system that may provide additional drawdown capacity during periods of drought.

The second phase of this 2-year project includes a seepage investigation to identify streams that are losing water to the ground-water system. This information along with a potentiometric map of the ground-water table will be used to select areas that may provide auxiliary water supplies in the Hixson Utility District service area. The project is under the direction of hydrologist Arthur Bradfield and is scheduled for completion in September 1988.



Location of the Hixson Utility District in Hamilton County, Tennessee.

DEVELOPMENT AND PROTECTION OF THE GROUND-WATER SOURCE OF DRINKING WATER IN THE EASTSIDE UTILITY DISTRICT

The Chattanooga-Eastside Utility District is one of the largest utilities in the State, supplying 3 to 4 million gallons of water per day to 26,000 customers in an area of about 50 square miles in southeastern Hamilton County. Since 1936, the water supply for Eastside has been obtained from Carson Spring either directly from the spring pool or from adjacent wells, just south of Wolftever Creek embayment of Chickamauga Lake. The flow of the spring varies seasonally ranging from a low of about 2.0 million gallons per day to an unknown high.

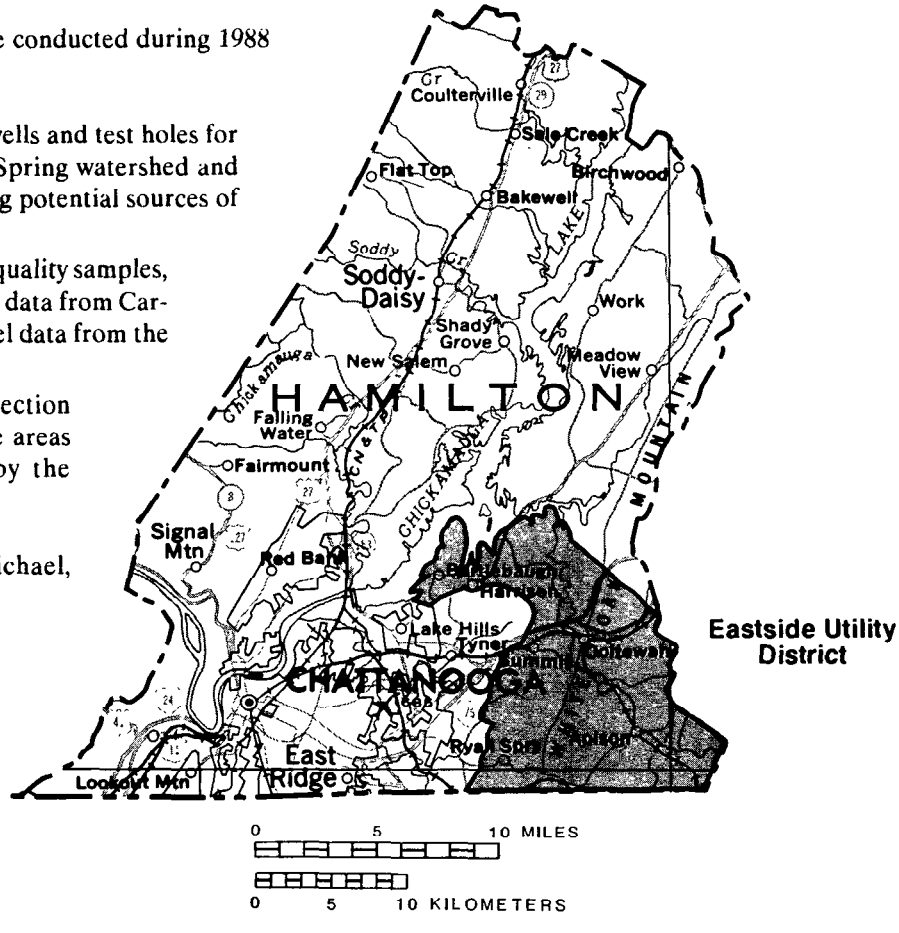
Although many springs in East Tennessee have been measured continuously by the USGS, there are no continuous flow records for Carson Spring. The USGS, in cooperation with the Eastside Utility District, is conducting an investigation to:

- Determine the average daily flow and any seasonal variations in the daily flow from Carson Spring.
- Define the size and geometry of the aquifer supplying the spring, as well as the extent of the drainage area contributing water to the aquifer.
- Investigate the availability of additional ground-water supplies within the 50-square-mile service area of the utility district.
- Interpret the hydrologic nature and water-supply potential of any additional sources.

Plans for Phase 2 of the project to be conducted during 1988 include:

- Drilling additional observation wells and test holes for production wells in the Carson Spring watershed and other areas identified as overlying potential sources of ground water.
- Collection and analysis of water-quality samples, continued collection of discharge data from Carson Spring and ground-water level data from the spring's watershed.
- Development of wellhead protection strategies for present and future areas of ground-water withdrawal by the Eastside Utility District.

The project leader is John Carmichael, hydrologist.



Location of Eastside Utility District in southeastern Hamilton County, Tennessee.

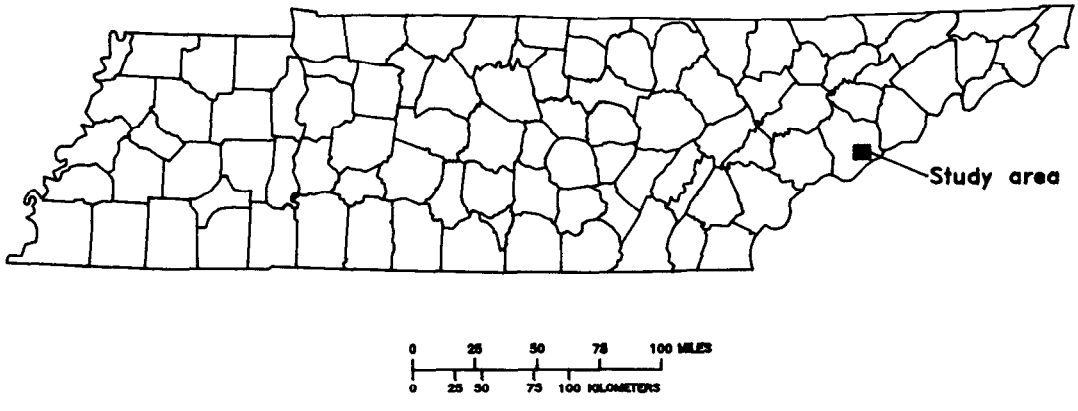
GROUND-WATER AVAILABILITY IN THE WEBB CREEK AREA, SEVIER COUNTY

In cooperation with the Webb Creek Utility District, the USGS is investigating the ground-water resources of Greenbrier Valley on the northern flank of the Great Smoky Mountains National Park. The purpose is to locate one or more year-round sources of supply for the utility district, and to provide information on the occurrence and movement of ground water in a narrow valley underlain by metamorphosed sediments, typical of many other valleys in the Blue Ridge province.

Six candidate sites have been selected for exploratory drilling, based on the following:

- Low-flow seepage investigation of Webb Creek.
- High-altitude photography.
- Geologic structure and characteristics of the geologic materials underlying the valley.
- Results of previous investigations in the Blue Ridge terrane.

Additional sites may be selected after the initial wells have been drilled. It is expected that the basic information on ground-water occurrence, quantity, and quality provided by this work will have application in developing water supplies for other utility districts and communities in the southeastern Appalachian Mountains. The project is headed by David Webster, hydrologist.



Location of Webb Creek Utility District study area in Tennessee.

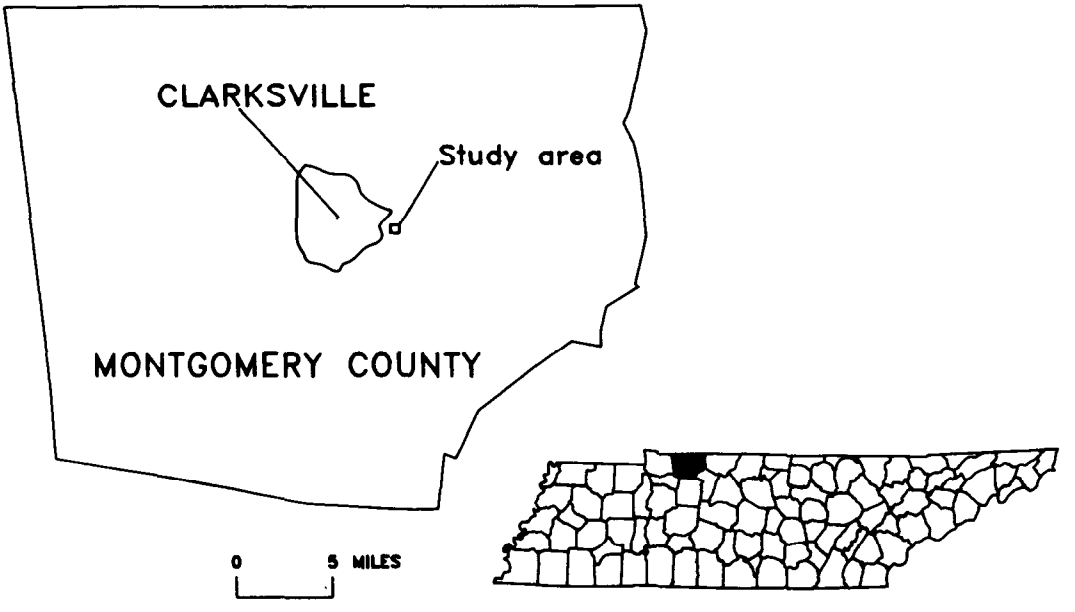
IMPACT FROM URBAN RUNOFF ON GROUND-WATER QUALITY

In many karst areas of Tennessee, drainage wells have been installed to accept stormwater runoff from urban areas in order to reduce surface flooding problems. This diversion can introduce contaminants such as:

- Oil and grease
- Trace metals
- Bacteria
- Salts
- Organic compounds

into the ground-water system, and thus alter the quality of ground water downgradient from the drainage well. In cooperation with the Division of Construction Grants and Loans of the Tennessee Department of Health and Environment, the USGS is conducting an investigation in the Clarksville area to determine the extent of any ground-water contamination due to diversion of runoff from a parking lot into a drainage well. The results of the investigation will assist the cooperator in designing a long-term monitoring strategy for ground-water quality in Tennessee.

Flow direction and velocity in the ground-water system have been determined by a flow-tracing investigation, in which dye injected at the sinkhole was recovered from a nearby spring. Time-series data has been collected at the drainage well and the spring during storm events to characterize the quantity and quality of runoff from the catchment area and the ground-water quality downgradient from the well. Up to five observation and sampling wells will be installed near the drainage well to provide additional sample points in the flow system. The project leader is Anne Hoos, engineer.

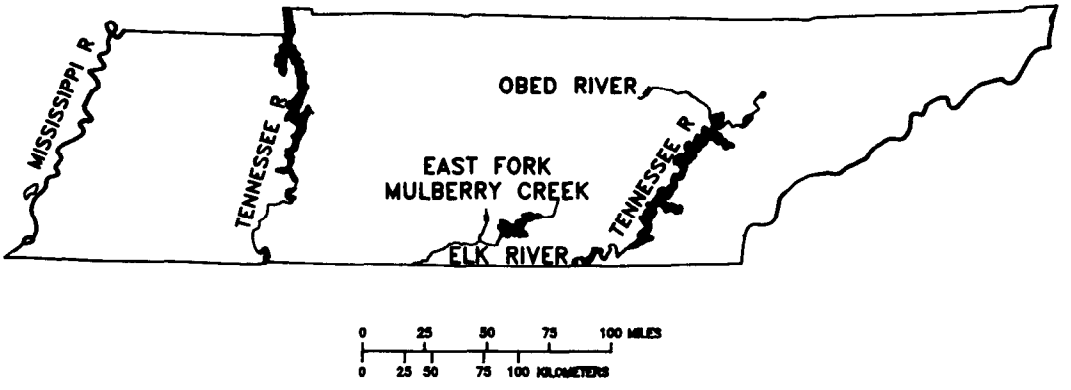


Location of study area near Clarksville, Tennessee.

REAERATION CHARACTERISTICS OF SELECTED STREAM REACHES IN TENNESSEE

Waste-load allocation to streams is based on the simulation of stream dissolved-oxygen concentration in response to waste loading. The accuracy of these simulations depends in large part upon an accurate determination of the reaeration coefficient, which defines the rate at which oxygen is physically absorbed from the atmosphere by the flowing stream. To date, the only procedure available for estimating this important parameter for Tennessee streams has been the use of empirical equations derived and verified for data collected outside of Tennessee.

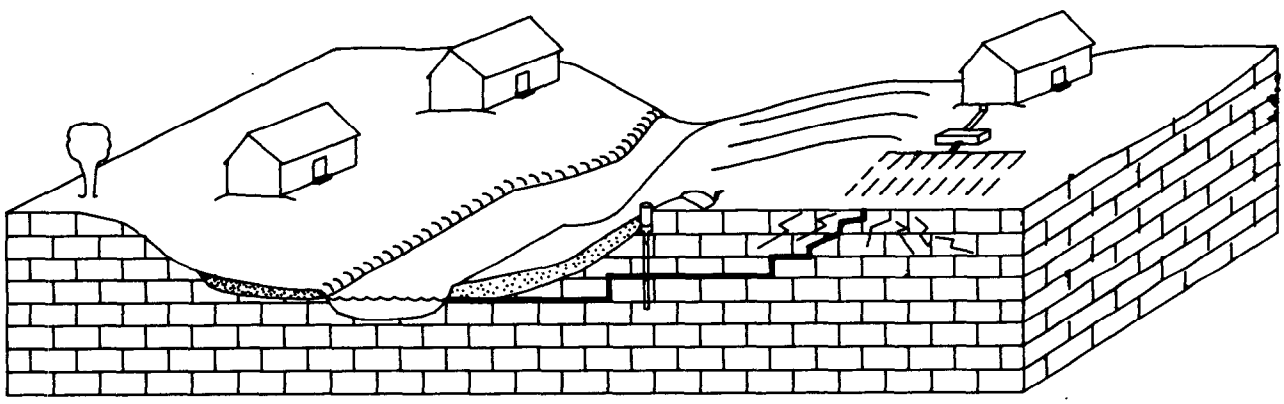
In cooperation with the Division of Water Pollution Control of the Tennessee Department of Health and Environment, the USGS conducted reaeration studies of the Obed River near Crossville and East Fork Mulberry Creek near Lynchburg. The study applied the innovative gas-tracer method, recently developed by USGS hydrologists, which permits direct calculation of the reaeration coefficient. Values of the coefficient were calculated for three consecutive reaches from each of the streams studied, and were compared to the predicted values from the empirical equations. Project leader is Anne Hoos, engineer, with assistance from Dr. Robert Broshears, engineer.



Location of the Obed River and East Fork Mulberry Creek in Tennessee.

IMPACT ON GROUND-WATER QUALITY OF BLASTED-IN SUBSURFACE SEWAGE SYSTEM FIELD LINES

Almost one-third of the population of Tennessee is served by subsurface sewage disposal systems, which are the largest of all contributors of wastewater to the ground. This public health problem is likely to be greatest in subdivided tracts in suburban areas, especially where field lines have been installed in blasted rock. The USGS, in cooperation with the Division of Construction Grants and Loans of Tennessee Department of Health and Environment, is undertaking an investigation to establish the nature and degree of relation between ground-water contamination and blasted-in field lines. The approach to achieve this objective includes sampling ground water at two test sites; one control site, where the subsurface is suitable for a septic system, and an experimental site, where the field lines have been blasted in. This study is being conducted by hydrogeologist E.F. Hollyday and geologist Dorothea Withington.



Block diagram showing flow of field line effluence from subsurface sewage system into blasted rock, to household well, and to nearby creek in subdivision using individual well-septic systems.

CHARACTERIZATION OF INFLOW OF PESTICIDES AND NUTRIENTS FROM STORM RUNOFF INTO REELFOOT LAKE, WEST TENNESSEE

An investigation is being conducted in cooperation with the Division of Construction Grants and Loans of the Tennessee Department of Health and Environment to define the contributions of nutrients and pesticides from storm events to Reelfoot Lake. Reelfoot Lake in West Tennessee, one of the most important natural resources in the State, is a key tourism and recreation area, a traditional commercial fishery, part of a National Wildlife Refuge and a State Conservation Area.

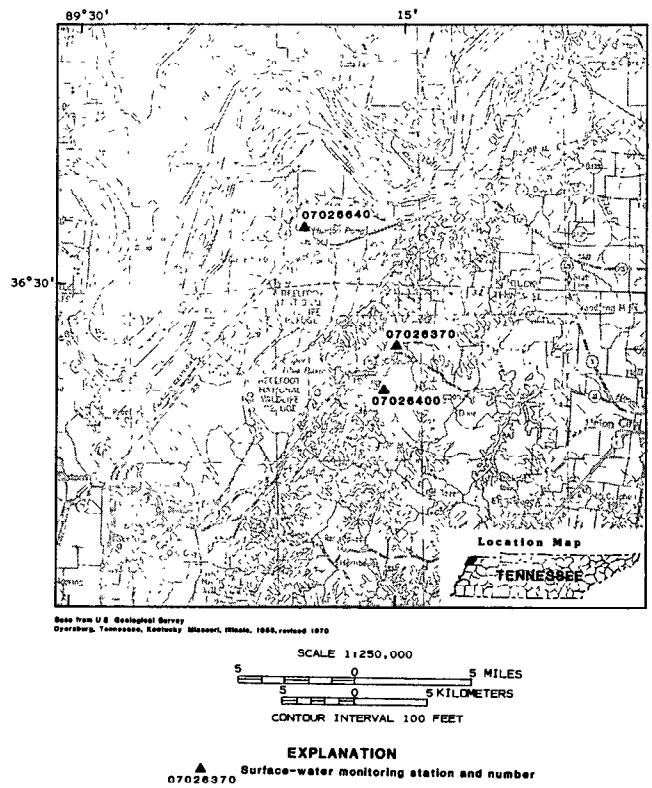
The specific objectives of the project are to:

- Define the concentrations of nutrients and pesticides relative to seasonal variation and stage for storm events of varied magnitude at three principal tributaries.

- Utilize time-concentration data and streamflow-suspended sediment records from existing stations at the three principal tributaries to the lake to estimate annual nutrient and pesticide loading from tributary inflow.

Although measurements of nitrogen concentrations in the waters of Reelfoot Lake are scarce, the available data indicate that Reelfoot Creek is an important source of nitrogen for the lake (TWRA, in press). Thus, a major source of these components in the lake is from inflows of the three principal tributaries (North and South Reelfoot Creeks, Running Slough). Agricultural activities in the basins of these tributaries contribute residues of fertilizers and pesticides to storm runoff that flows into the lake. The extent of the contribution and the percentage contributed by storms of different magnitude have not been defined. The annual budget of nutrients and pesticides flowing to the lake is poorly quantified.

Engineer Bill Carey is the project chief.

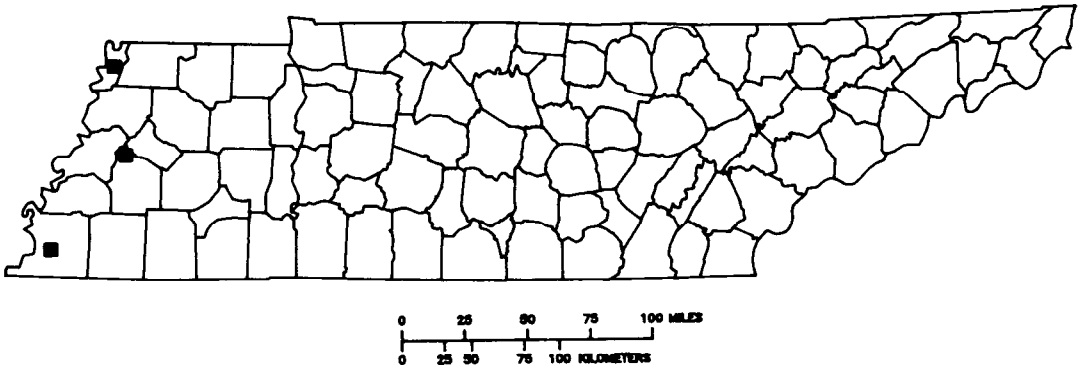


Location of project area, Reelfoot Lake, and surface-water monitoring stations.

RECONNAISSANCE OF THE IMPACT OF AGRICULTURAL CHEMICALS ON GROUND-WATER QUALITY

The USGS, in cooperation with the Tennessee Department of Health and Environment, Division of Construction Grants and Loans, is conducting an investigation to determine the effects of agricultural chemicals on ground-water quality. For this study, selected shallow wells at three sites are being sampled for concentrations of nutrients and pesticides. Sampling sites, located in Shelby, Lake, and Haywood Counties, were chosen to represent the three major agricultural products of West Tennessee: corn, soybeans, and cotton. All wells are located near fields under active cultivation.

One sampling run has been completed and another is scheduled for May-June 1988. The analyses from these sampling events will provide an indication of the impact of agricultural chemicals on ground-water quality. A report documenting the results of this study will be completed in December 1988. The project leader is Dorothea Withington, geologist.



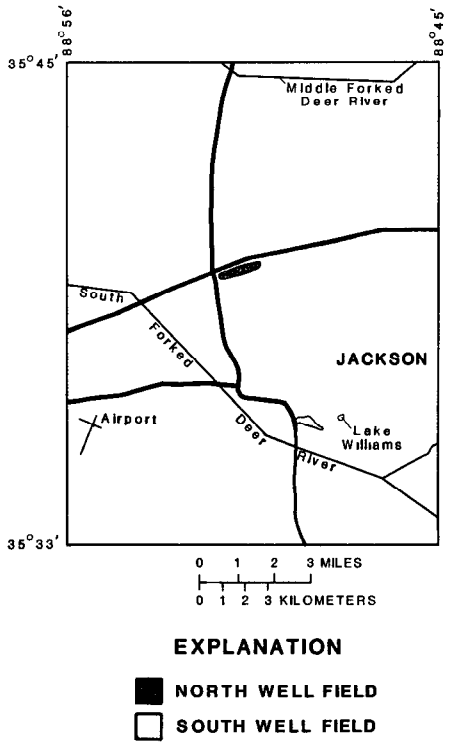
Location of sampling sites in Haywood, Lake, and Shelby Counties.

PRELIMINARY ASSESSMENT OF THE HYDROGEOLOGY AND POTENTIAL SOURCES OF GROUND-WATER CONTAMINATION AT JACKSON, TENNESSEE

In 1987 the USGS, in cooperation with the Division of Groundwater Protection of the Tennessee Department of Health and Environment and Jackson Utility Division, selected the city of Jackson, Tennessee, as the site for an investigation to demonstrate the factors to be considered in developing a local plan for ground-water protection. The purpose of the investigation was to provide preliminary information and analyses for the development of a wellhead protection program. The investigation was limited to a preliminary assessment of the local hydrogeologic framework, current ground-water quality, and potential sources of ground-water contamination. Preliminary data were used to demonstrate several methods for the delineation of wellhead protection areas.

The utility, in Madison County, pumps about 9 million gallons of ground water daily from an unconfined aquifer. This aquifer comprises Eocene sands of the Wilcox and Claiborne Groups. Under natural hydraulic gradients, ground water flows toward the utility's south well field at approximately 2 to 3 feet per day; natural flow toward the utility's north well field is from the east at 1 to 2 feet per day. Water quality is generally good, as dissolved solids are low, and excessive iron concentrations are the only significant naturally occurring problem. However, trace concentrations of volatile organic compounds have been detected in water pumped from the south well field; the highest concentration of a single compound has been 23 μg/L of tetrachloroethylene. Potential sources of ground-water contamination in the Jackson area include a CERCLA and RCRA site, wastewater-discharge sites, municipal and industrial landfills, and underground storage tanks. Methods suggested by the U.S. Environmental Protection Agency for the delineation of wellhead protection areas were evaluated, and a uniform flow equation was used to map zones of contribution for the utility's well fields and to delineate ground-water time-of-travel contours. Recommendations were made for a more rigorous assessment of ground-water flow in the Jackson area, including development of a numerical flow model.

The project leader for the investigation is Dr. Robert E. Broshears.



Location of Jackson study area.

INDEX OF GEOGRAPHIC INFORMATION SYSTEMS (GIS) IN TENNESSEE

Within the last 4 years, the number of computerized mapping systems, commonly called Geographic Information Systems (GIS), within Tennessee has increased rapidly. In order to examine the present status of GIS efforts, the Tennessee State Planning Office and the USGS entered into a cooperative agreement to collect information about mapping usage, computer equipment, GIS software, and existing digital data.

The objectives of the project are as follows:

- Perform a survey of existing mapping coverages, location of specific data bases, available transformation software, and transfer techniques that exist at various state, federal, county, and municipal agencies.
- Ccreate a computer data base of the results of the survey.
- Develop suggested standards for digitized data.
- Describe, in general, communications techniques that can be used to transfer data from one system to another.
- Create a map coverage of Tennessee and the 7.5-minute quadrangle maps within the State and allow identification of existing map coverages for each.
- Publish a reference guide containing information obtained from the above.

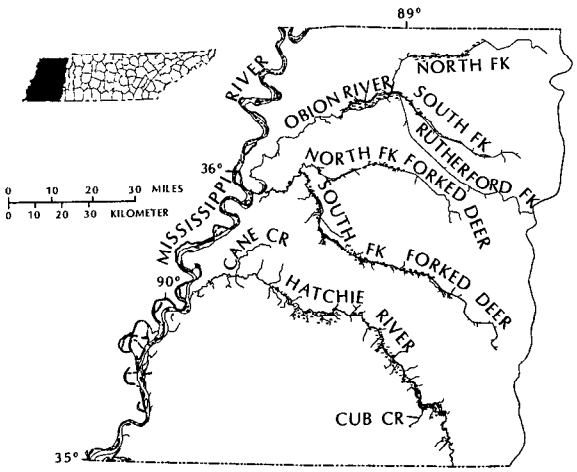
As of March 1988, 63 offices had been contacted. Twelve GIS systems were in operation, and 841 map coverages had been developed. The data base for storage of the above information has been completed and the data entered. Input forms for the data base and retrieval programs have also been completed. In addition, the 7.5-minute quadrangle coverage of the State is near completion.

ANALYSIS OF SEDIMENT DEPOSITION IN WETLANDS IN RELATION TO BRIDGE STRUCTURES

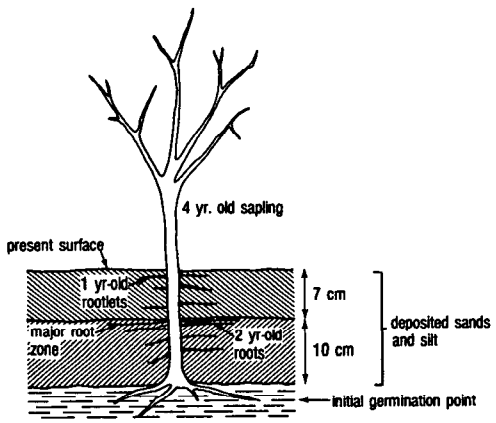
In cooperation with the Tennessee Department of Transportation, the USGS is conducting a study of sedimentologic processes and sediment storage in riverine wetlands. The objectives of the study include:

- Determination of the amount and rate of sediment deposition using data obtained from affected bottomland trees, artificial substrates, and single-stage sediment collectors.
- Determination and interpretation of wetland species responses using tree-ring analysis.
- Determination of the effects of ridge structures on sedimentation processes and normal hydroperiod in adjacent wetlands.

Ten wetland sites near bridge structures have been selected for detailed study in West Tennessee. Control wetlands occur near each site. Instrumentation of sites, plant ecological analysis, sedimentological analysis, and tree-ring analysis have begun at several of the study sites. Initial results suggest that analysis of buried trees provide accurate rates of recent sedimentation and allow for the determination of the relative effects of bridge structures. Additionally, several species of bottomland trees may be highly indicative of ambient depositional conditions. Tupelo gum appears to be particularly tolerant of high sedimentation rates, while hydric oaks are not. The study, scheduled for completion in 1990, is directed by Dr. Cliff R. Hupp, botanist.



Location of study streams in West Tennessee.



Generalized buried tree. Excavation of tree and tree-ring analysis yield amount and rate of deposition.

FLOOD FREQUENCY

This project is a part of the Flood Investigations project and is being undertaken in cooperation with the Tennessee Department of Transportation (TDOT). The project involves the updating of a previous flood-frequency regionalization report published in 1976. It will use data collected at the crest-stage partial-record stations (described under Flood Investigations) along with data from the regular gaging station network. A station flood-frequency curve will be computed for each site. Peak discharges for selected recurrence intervals for each station and selected basin characteristics will be used in a regression analysis to define regional equations for computing peak discharge at ungaged sites. Further statistical analyses will be made to determine the accuracy of the estimating equations and to pinpoint the source of the error of the estimates. The prediction error for ungaged sites can be divided into model error and sampling error (including both time- and spatial-sampling error).

The project is statewide and the project chief is hydrologist Charles Gamble.

GEOCHEMICAL AND GEOMICROBIAL PROCESSES AFFECTING THE FATE OF ORGANOCHLORINE PESTICIDES IN GROUND WATER

In cooperation with Memphis State University, the USGS is studying geochemical and geomicrobial processes affecting the fate of organochlorine pesticides in ground water. Organochlorine pesticides include chlordane, heptachlor, and lindane. These compounds are the chemicals of primary concern at three of the seven hazardous-waste sites in Tennessee currently on the U.S. Environmental Protection Agency's National Priority List. They pose potential health risks via ground-water pathways at these sites and at other locations around the country.

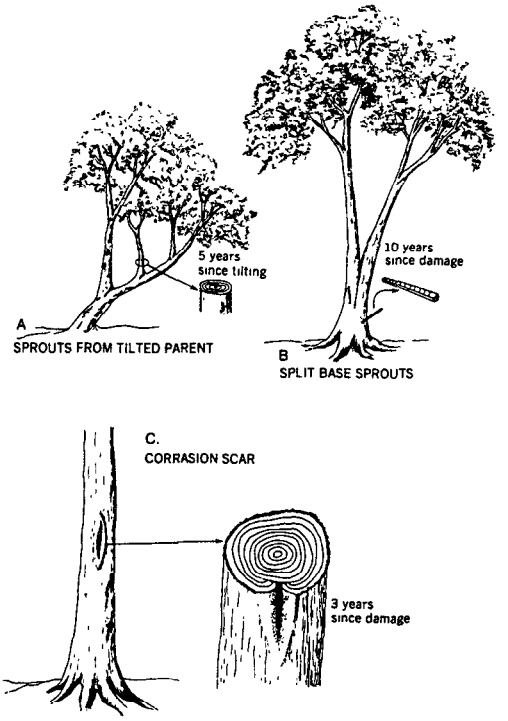
The specific objectives of the study are the understanding and quantification of key processes affecting the fate of organochlorine pesticides in saturated subsurface environments. These processes include solubilization, sorption, and biotransformation. Pesticide solubility will be quantified and geochemical controls on solubilization will be assessed. Sorptive behavior, including the influence of water and solid-surface chemistry, will be quantified. Biotransformation pathways will be defined, and factors determining degradation rates and products will be identified.

The project chief is Dr. Robert E. Broshears.

FLOOD-FREQUENCY INVESTIGATIONS AT PROBLEMATIC OR UNGAGED STATIONS USING BOTANICAL EVIDENCE AND MAXIMUM LIKELIHOOD ESTIMATORS

This study, located largely in the Tennessee River valley, uses botanical evidence of floods as historic information in maximum likelihood statistical procedures. These techniques, while still experimental, are highly valuable in extending flood records, reducing standard errors, and in particular, in developing accurate flood-frequency curves for ungaged basins. Dr. Cliff R. Hupp (botanist) and Bradley A. Bryan (hydrologist) are the project leaders.

Several streams with short or problematic gaging-station records have been investigated. A few streams with long systematic records have been investigated as test cases for the procedures. Botanically determined dates of flooding, estimated stage characteristics for each flood, and flood-perception thresholds are entered into a computer maximum likelihood program, from Cornell University, that develops flood-frequency curves with standard-error, confidence-interval, and marginal-gain information. Results have shown that substantial reduction of standard errors and confidence intervals at several flood-return periods may be achieved using these techniques. Marginal-gain analysis shows that 100 years of botanical record is equivalent to 37 years of systematic record for some studied streams. These procedures have been used successfully to improve the flood record on streams where there existed a wide divergence between the flood-frequency curve estimated by systematic records and regional-flood equations. The maximum likelihood program using index-flood information will establish flood-frequency curves for ungaged streams with on-site botanical information. This project is supported by the Tennessee Department of Transportation, the Office of Surface Water of the USGS, and the Tennessee Valley Authority.



Botanical evidence of floods.

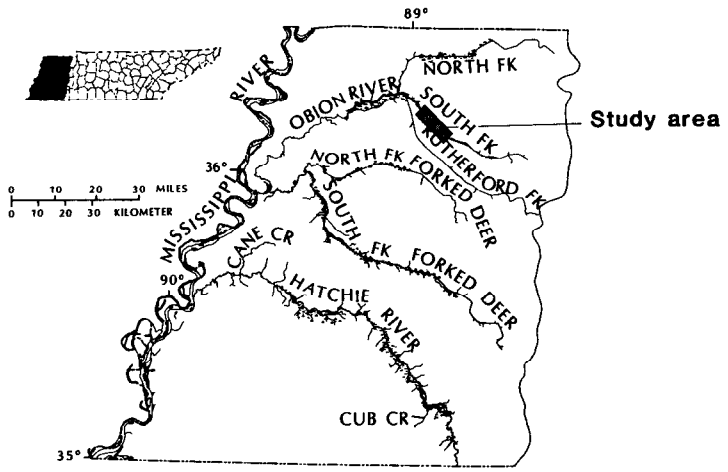
SIDONIA PROJECT

This project involves a study of about an 8-mile reach of South Fork Obion River (designated the Sidonia Item by the Memphis District, Corps of Engineers) in cooperation with the Tennessee Department of Health and Environment (TDHE). The objective of the project is to determine the hydraulic and environmental effects of the proposed channelization of this reach of South Fork Obion River by the Corps of Engineers as related to:

- Bankfull discharge and frequency.
- Sediment-transport rates.
- Channel erosion and deposition.
- Bank stability.
- Wetland hydroperiod.
- Ground-water table elevations.

The field and analytical techniques to be used in this investigation are multidisciplinary, including hydrology and hydraulics, geomorphology, soil mechanics and slope stability, geobotany, and ground-water modeling.

Some of the results of this study may have transfer value to other areas where channelization may affect these same environmental factors. Project chief is Charles Gamble, hydrologist.



Location of the Sidonia study area.

DOCUMENTATION OF MILLINGTON FLOOD

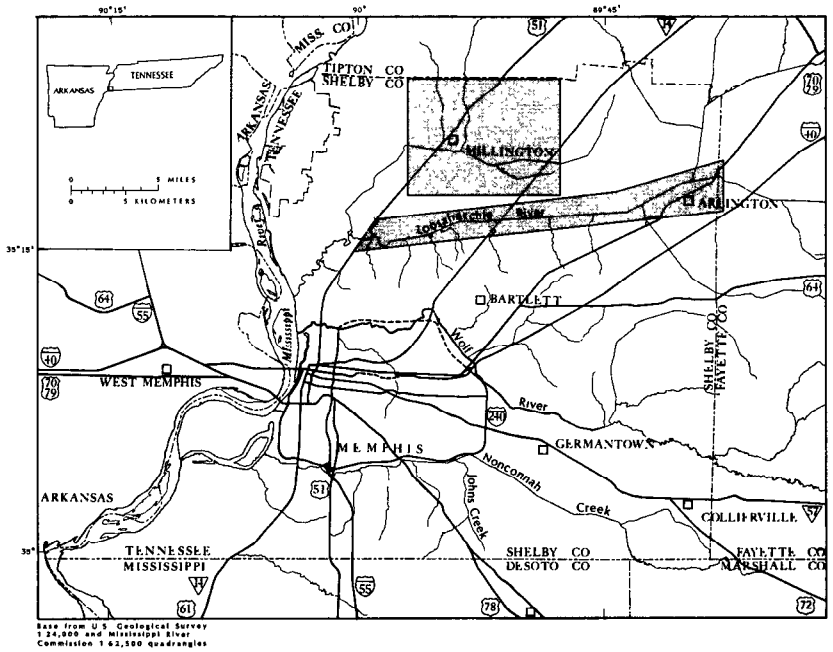
In cooperation with Shelby County and the City of Millington, Tennessee, the USGS has a project to document the flood of December 25, 1987, in the city of Millington and in northern Shelby County (Loosahatchie River). Preliminary data indicate that this flood on the Loosahatchie River was about a 50-year flood, and on Big Creek and some of its tributaries in Millington, it may have been a 100-year flood or greater.

The documentation will include:

- Flood profiles for the streams involved.
- Computation of peak discharges and frequencies for Big Creek and North Fork Creek in Millington.
- Delineation of flooded areas and flood depths in Millington.

The data will be published as a Hydrologic Atlas and should be very helpful to local officials in planning for future flood-protection measures, zoning, and updating of flood insurance studies.

The project chief is hydrologic technician James G. Lewis in the Knoxville Subdistrict office.



Location of the Millington study area.

APPALACHIAN VALLEYS-PIEDMONT REGIONAL AQUIFER-SYSTEMS ANALYSIS

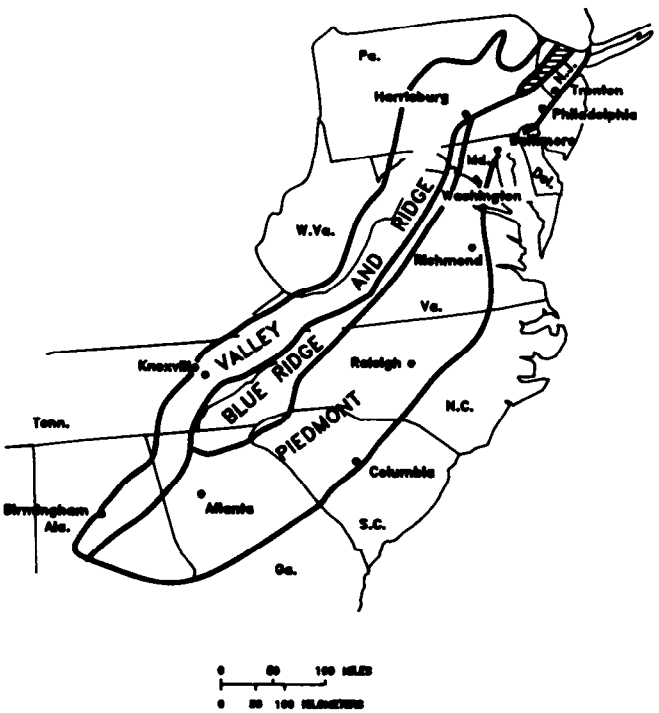
The Appalachian Valley and Ridge, Blue Ridge, and Piedmont physiographic provinces of the eastern United States cover about 145,000 square miles from the northern New Jersey border to Birmingham, Alabama. If this region is to be able to supply the water resources needed as it continues to develop, it is imperative that the resources of the area be understood. It is intended that the Appalachian-Piedmont Regional Aquifer-Systems Analysis (RASA) study develop that understanding and provide the necessary information. The project is supported by federal funds.

The specific objectives of the study are to:

- Delineate and describe the ground-water flow systems within each of the provinces and to subdivide further the provinces by lithology, structure, and topography.
- Develop an understanding of the processes controlling recharge and discharge in the region.
- Provide regional estimates of ground-water pumpage, natural discharge, and ground-water recharge and storage.
- Develop prototype mathematical models of the flow systems that represent "type" areas as an aid in understanding flow systems in other locations with similar geology, structure, and topography.
- Develop a comprehensive data base capable of supporting mathematical modeling of basins throughout the region as the need develops.
- Determine the importance and interrelational surface-water and ground-water flow systems within the region and their effects on water quality.

The approach to be taken in this study will be to identify and quantify specific hydrologic components at selected "type" areas from which an understanding of these characteristics can be transferred to other areas with similar geologic and hydrologic conditions.

Project chief of the Tennessee subregion is E.F. Hollyday, hydrogeologist.



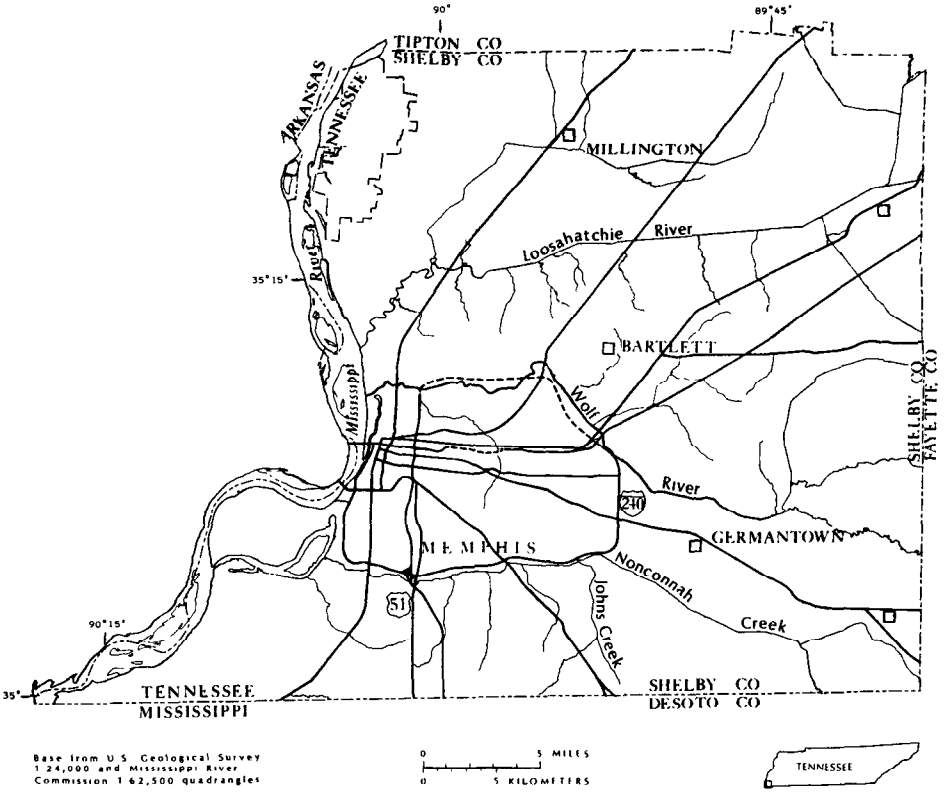
Location of the Appalachian Valleys-Piedmont Regional Aquifer-Systems Analysis study area.

DEVELOPMENT OF A GEOGRAPHIC INFORMATION SYSTEM FOR MANAGING GROUND-WATER RESOURCES IN THE MEMPHIS-SHELBY COUNTY AREA, TENNESSEE

The USGS, in cooperation with Shelby County (Memphis-Shelby County Health Department) and the City of Memphis Light, Gas and Water Division (MLGW), will develop a Geographic Information System (GIS) to assist in the management of the ground-water resources in the Memphis-Shelby County area. The GIS will contain all available ground-water data for the shallow and deep aquifers in the area. The data will be supplemented with other geographic information including, but not limited to, soils, surface geology, sources of contamination, streams, topography, and land use.

A key element of the project will be the development of a computerized data base to store all the available well data in the county. The well data, including location of wells, construction, physical characteristics of the boreholes, water levels, and quality of the water from the wells, will be stored on a priority basis to provide Shelby County with an effective tool in the management of their ground-water and wells-permitting programs. The GIS will initially be installed at the USGS computer facilities in the Memphis office. The initial phase of the project will begin in 1988 and will consist of acquiring both computer software and hardware. Project personnel will be assigned and training will commence in 1988. In the following 2 years, all available ground-water data will be entered into the GIS on a priority basis. Updates to the system will be made on a continuous basis.

Real-time access will be provided to MLGW and Shelby County to be undertaken to transfer the GIS to the MLGW computers. Susan S. Hutson, hydrologist, will be the project leader.



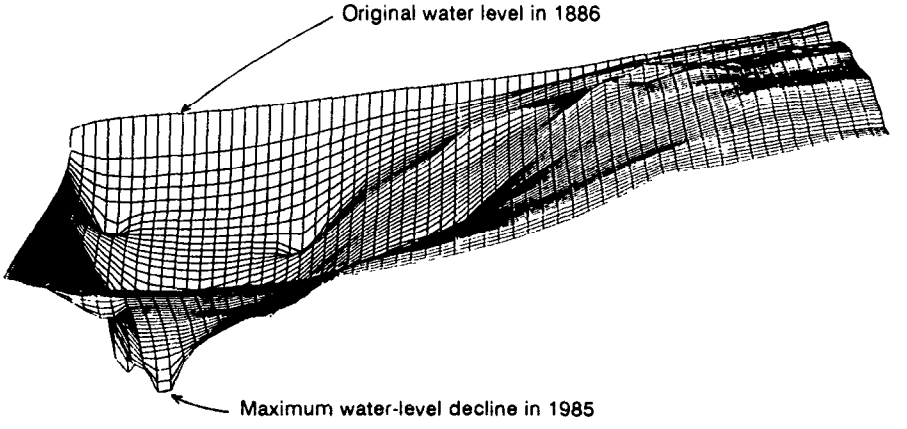
Location of the Memphis-Shelby County study area.

HYDROGEOLOGY OF THE MEMPHIS SAND AND FORT PILLOW SAND AQUIFERS

The USGS, in cooperation with Memphis Light, Gas and Water Division, is quantitatively assessing the ground-water resources of the major deep aquifers in the Memphis area, the Memphis Sand and the Fort Pillow Sand. A three-dimensional ground-water flow model developed exclusively for this study is serving as the primary tool with which to make the assessment.

The purpose of the model, which will ultimately be used as a tool to evaluate management alternatives, is to aid in understanding the hydrology of the complete system of aquifers in the area. Because leakage from shallow to deeper aquifers occurs, and because the shallow aquifers may contain water of inferior quality, it is essential to establish the location of leakage and recharge, and to know what flow directions water from these locations may follow if it is introduced into the aquifer. The flow model allows such calculations to be made. The model also shows the effects of changing pumping distributions within existing well fields and the effects of adding new well fields to the system.

Project chief Dr. John Van Brahana, geologist, assisted by Dr. Robert E. Broshears, engineer, has completed calibration of the model and has submitted the report, which is currently in review.



Effects of pumping from the Memphis Sand calculated by flow model.

WAYNE COUNTY LANDFILL INVESTIGATION

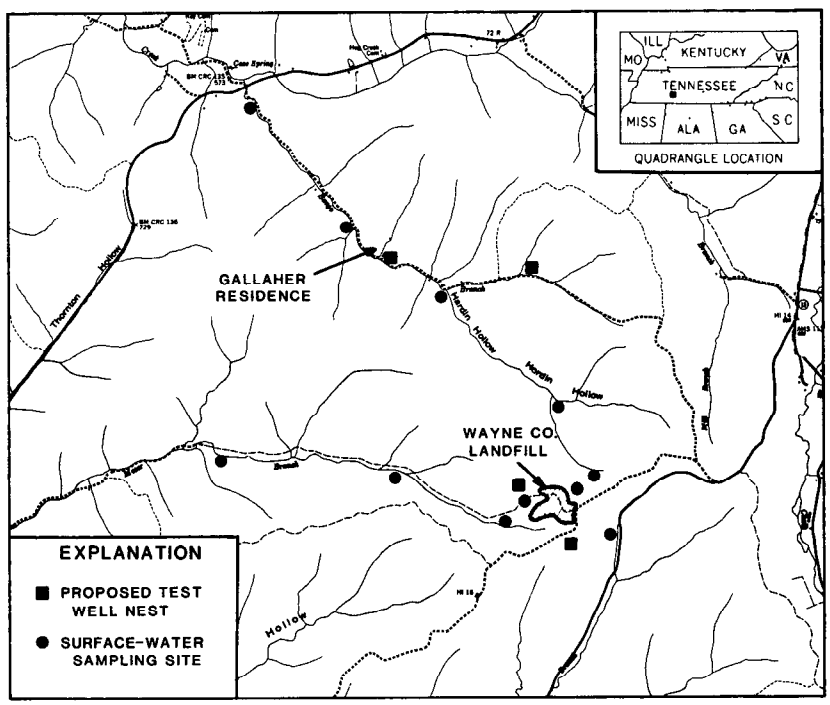
The USGS, in cooperation with the Tennessee Department of Health and Environment, Division of Superfund, has undertaken a hydrologic and geologic investigation of the area surrounding the recently closed landfill in Wayne County, Tennessee. The 10-year-old landfill is situated upon a ridgetop in the Mississippian age Fort Payne Formation.

The objectives of the investigation are to:

- Define the hydrogeology of the area and potential contaminant pathways from the landfill.
- Determine background and present chemical quality of ground water and surface water, including sediment.
- Determine the nature and chemical composition of leachate from the disposal site.
- Determine the nature and extent of contaminants in the project area.

Planned activities for the project include installation of a stream gage, installation of monitoring wells, multiple injection point dye tracing, water-quality sampling and analyses, and bottom sediment sampling in streams. Drilling of monitor wells began in March, 1988.

The project is scheduled for completion in April 1989. The project chief is Roger Lee, geochemist.



Location of Wayne County landfill study area.

OTHER ACTIVITIES

COOPERATIVE EDUCATION STUDENTS ASSIST IN PROGRAMS

The USGS in Tennessee is actively involved in cooperative education programs with colleges and universities across Tennessee. The program has been in effect for about 15 years. Cooperative Agreements between the schools, U.S. Office of Personnel Management, and the USGS have been initiated at seven colleges and universities in the State. Presently, the USGS has eight coop students from three universities working in six offices.

Coop students work alongside the USGS career professional staff of engineers, geologists, chemists, computer specialists, technicians, and cartographers. They participate in all phases of the investigations conducted by these career professionals - hydrological data collection and processing, research into water problems such as supply and contamination, open-channel flow hydraulics, ground-water hydraulics and modeling, impacts of channel modifications, computer operations and programming, cartography and drafting, and the scientific procedures and methodology used in these scientific and research fields. After initial training is finished, early in the first work term, many of these students perform tasks usually assigned to professional career staff. Reviews conducted by career staff assures that the work is done properly and ensures that training is adequate and continuing. Most students come to work for a term of 6 to 12 months, return to school, and then return for another work term.

The coop student work program provides excellent assistance to the USGS in accomplishing its program and objectives in Tennessee. In addition, the program identifies outstanding potential employees that may choose to seek a professional career with the USGS upon graduation. The USGS assigns a high priority to this program and views it as a study-work partnership between Tennessee colleges and universities and the USGS. Overall, the benefits to the USGS and students have been positive and excellent to all involved. Several of the students are now full-time USGS career professional employees. Jeff May, Assistant District Chief, directs the USGS's coop program in Tennessee.

GROUND-WATER INFORMATION UNIT

The objectives of this newly formed support unit are to ensure maximum utilization of ground-water data collected in Tennessee and to provide diverse support for all ground-water activities in the District. Specific functions of the Ground-Water Information Unit are to:

- Store new ground-water data.
- Clean-up and maintain ground-water data bases.
- Assist personnel in retrieving and plotting data.
- Answer information requests.

The ground-water computer data base maintained by the District is part of a national system run by the USGS, and currently contains information on over 2,600 ground-water sites in Tennessee. Data from the District's data base can be output directly as tables and hydrographs, or can be output to a geographic information system for combining and plotting with other data.

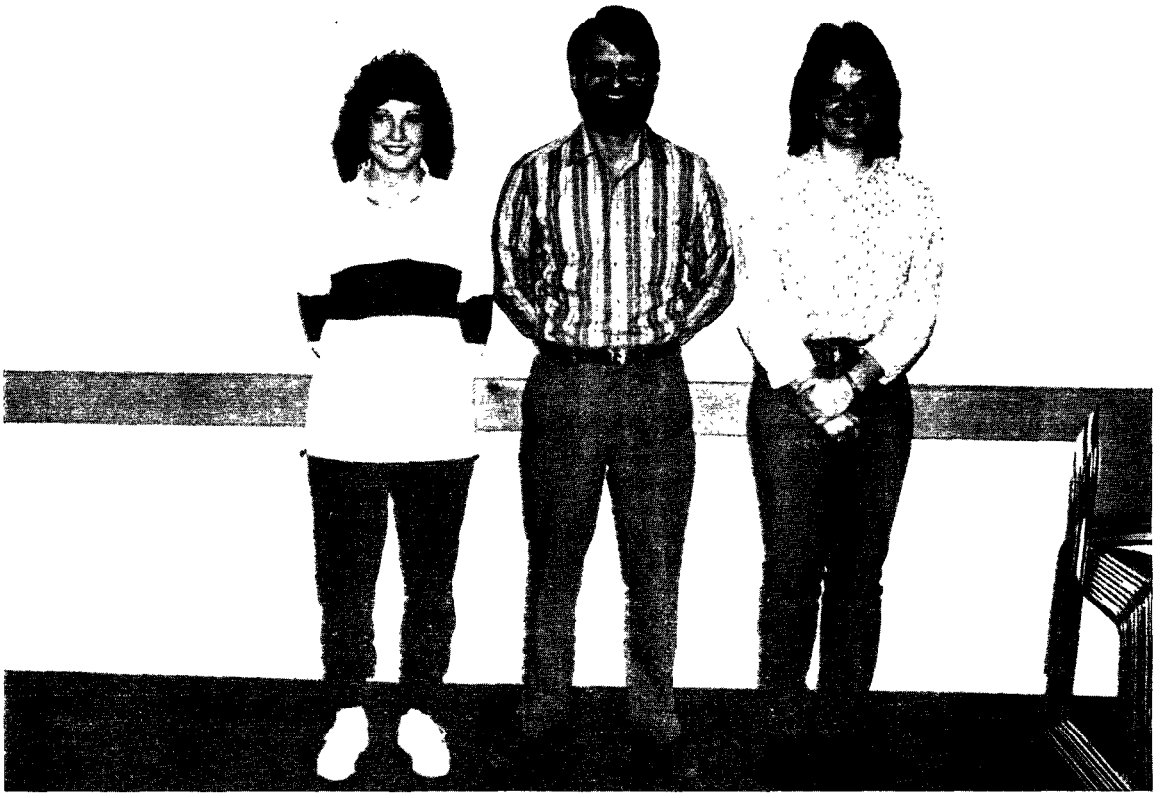
COMPUTER SECTION AND CAPABILITIES

The Tennessee District continued to improve and expand its computer capabilities in support of its programs and cooperators. During 1987, the following milestones were accomplished:

- Six personal computers were installed at various offices in the District. These units are being used for word processing, graphics, and desktop publishing applications.
- In August 1987, the Automated Data Processing System (ADAPS) was installed. All of the District historical data for continuous-record stations were converted. ADAPS has been especially useful for processing our increasing number of satellite stations.
- In October 1987, a Prime 9955-II was installed, replacing the Prime 750. This increased computer power by a factor of four.
- In December 1987, an additional 600 megabyte disk drive was installed, bringing our total storage capacity to 1,800 megabytes.
- Arc/Info was installed on this disk drive in January 1988, allowing the District to begin using digital data for producing spatial graphics.

Next year's plans include the enhancement of district telecommunications with the Subdistrict offices, the acquisitions of additional microcomputers, the refining of Arc/Info skills, the development of programs on the microcomputers, and the development of Arc/Info relations with other agencies.

The computer staff currently consists of Bill Barron, site manager; Joe Connell, Arc/Info specialist; Linda McCashland, computer operator; and Pam Norris, programmer trainee.



The Computer Unit personnel.

REGIONAL PUBLICATION CENTER

The Tennessee district operates a Regional Publication Center and Clearinghouse in support of projects within the District and the 10 other states in the Southeastern Region. Barbara Balthrop is the Chief of the Publication Center. The following is a list of the Center's accomplishments during 1987 and its goals for 1988.

Accomplishments for 1987:

- Staff increased with the hire of two cartographic technicians and one clerk-typist.
- Acquisition of personal computers and specialized software for desktop publishing and publication-quality computer graphics preparation.
- Printing of the "Standards of Illustrations in Reports for the U.S. Geological Survey, Water Resources Division".
- Establishment of a term printing contract for publication of reports.

Goals for 1988:

- Hire of additional personnel to increase Center staff.
- Acquire additional personal computer systems with graphics software.
- Establish a Southeastern Region cartographic services contract for use by all Districts

The Regional Publication Center personnel.

RECENT PUBLICATIONS

The Tennessee Center prepared for publication 3 Water-Resources Investigations Reports, 3 Open-File Reports, 11 journal articles and abstracts, 1 conference program with abstracts, and 6 articles for symposia proceedings. Layout and paste-up for 2 WRD Bulletins for the USGS National Headquarters were completed along with the printing of 6 out-of-District reports. Currently, there are 24 reports in various stages of preparation. In addition to the informal and formal report series work, the Tennessee Center also has published 5 bi-monthly bulletins.

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Brahana, J.V., and Mesko, T.O., 1988, Hydrogeology and preliminary assessment of regional flow in the Upper Cretaceous and adjacent aquifers in the northern Mississippi embayment, WRIR 87-4000.

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Hollyday, E.F., and Balthrop, B.H. (compilers), 1987, Abstracts with program of ground water: Tennessee's hidden asset, A conference: May 6-7, 1987, Nashville, Tennessee.

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Quinones, Ferdinand, Balthrop, B.H., and Baker, E.G., 1987, Water resources investigations in Tennessee: Programs and activities of the U.S. Geological Survey, 1986-1987, OFR 87-231.

Tucci, Patrick, 1988, Surface-geophysical investigations in Melton Valley, Oak Ridge Reservation, Tennessee, WRIR 87-4184.

ADMINISTRATIVE SERVICES SECTION

Administrative services to the Tennessee District headquarters and field offices are provided by a unit of four employees directed by Nancy Tedder, Administrative Officer. Personnel management, payroll, training, procurement, inventory control, budgeting, and accounting services are efficiently handled through computerized systems.

The Administrative Services Section personnel.

APPENDIX 1

Active Recording Surface-Water Stations in Tennessee as of 2/29/88

Station No.	Name	Drainage area (mi^2)	Lat	Long	Date began
	CUMBERLAND RIVER BASIN				
03408500	New River at New River	382	362308	843317	1934
03409500	Clear Fork near Robbins	272	362318	843749	1930
03414500	E Fork Obey River nr Jamestown	202	362458	850135	1942
03416000	Wolf River near Byrdstown	106	363337	850423	1942
03417500	Cumberland River at Celina	7,307	363315	853052	1922
03417600	Cumberland River at Penitentiary Branch	7,440	362621	853542	
03418070	Roaring River above Gainsboro	210	362104	853245	1974
03421000	Collins River near McMinnville	640	354232	854346	1925
03422500	Caney Fork near Rock Island	1,678	354826	853744	1911
03425000	Cumberland River at Carthage	10,690	361453	855719	1922
03425100	Cumberland River at Rome	10,866	361550	860410	
03427500	East Fork Stones River nr Lascassas	262	355506	862002	1951
03428200	W Fork Stones River at Murfreesboro	128	355410	862548	1972-82, 1986
03428500	West Fork Stones River near Smyrna	237	355625	862754	1965
03430118	McCrory Cr at Ironwood Dr, at Donelson	7.31	360908	863901	1977
03431062	Mill Creek trib. at Glenrose Ave., at Woodbine	1.17	360702	864337	1977
03431490	Pages Branch at Avondale	2.01	361222	864624	1977
03431517	Cummings Branch at Lickton	2.40	361825	864800	1975
03431700	Richland Creek at Charlotte Avenue, at Nashville.	24.3	360904	865116	1964
03432350	Harpeth River at Franklin	191	355514	865156	1974
03433500	Harpeth River at Bellevue	408	360316	865542	1920
03434500	Harpeth River near Kingston Springs	681	360719	870556	1925
03435000	Cumberland River below Cheatham Dam	14,163	361926	871332	1954
03435008	Cumberland River nr Clarksville	14,421	362956	871948	
03436000	Sulphur Fork Red River near Adams	186	363055	850332	1939
03436100	Red River at Port Royal	935	363317	870831	1961
03436690	Yellow Creek at Ellis Mills	103	361839	873315	1980

Active Recording Surface-Water Stations in Tennessee as of 2/29/88--Continued

Station No.	Name	Drainage area (mi^2)	Lat	Long	Date began
	TENNESSEE RIVER BASIN				
03455000	French Broad River near Newport	1,858	355854	830940	1900
03465500	Nolichucky River at Embreeville	805	361035	822727	1920
03466228	Sinking Creek at Afton	13.7	361155	824431	1977
03470500	French Broad River near Knoxville	5,101	355730	834626	1946
03490500	Holston River at Surgoinsville	2,874	362819	825050	1941
03491000	Big Creek near Rogersville	47.3	362534	825707	1957
03495500	Holston River near Knoxville	3,747	360056	834954	1930
03497300	Little River above Townsend	106	353952	834241	1963
03498500	Little River near Maryville	269	354710	835304	1951
03498860	Little River at Alcoa Water Plant nr Maryville	301	354832	835545	
03528000	Clinch River above Tazewell	1,474	362530	832354	1918
03535912	Clinch River at Melton Hill Dam	3,343	355307	841803	1936
03536320	White Oak Creek near Melton Hill	1.31	355556	841820	1987
03536380	Whiteoak Creek near Wheat				1987
03536440	Northwest Tributary near Oak Ridge	.67	355518	841913	1987
03536450	First Creek near Oak Ridge	.33	355521	841910	1987
03536550	Whiteoak Creek bl Melton Valley Drive near Oak Ridge	3.28	355510	841902	1985
03537050	Melton Branch trib. (East Seven) near Oak Ridge	.24	355507	841743	1987
03537100	Melton Branch near Melton Hill, nr Oak Ridge	.52	355459	841753	1985
03537200	Melton Branch trib. (Center Seven) near Oak Ridge	.07	355503	841754	1987
03537300	Melton Branch trib. (West Seven) near Oak Ridge	.15	355511	841808	1987
03538225	Poplar Creek near Oak Ridge	82.5	355955	842023	1960
03538250	East Fork Poplar Creek near Oak Ridge	19.5	355758	842130	1960
035382672	Bear Creek trib. abv Bear Creek Road near Wheat	.30	355641	841927	1986
035382673	Bear Creek near Wheat	3.20	355639	841927	1986
035382677	Bear Creek tributary near Wheat	.14	355628	841955	1987
03538270	Bear Creek at State Hwy 95 near Oak Ridge		355617	842029	1985
03538272	Bear Creek trib. at Hwy 95 near Wheat	.14	355626	842032	1986
03538273	Bear creek at Pine Ridge near Wheat	5.00	355632	842037	1986
03540500	Emory River at Oakdale	764	355859	843329	1927

Active Recording Surface-Water Stations in Tennessee as of 2/29/88--Continued

Station No.	Name	Drainage area (mi^2)	Lat	Long	Date began
	TENNESSEE RIVER BASIN--continued				
03543500	Sewee Creek near Decatur	117	353453	844453	1934
03560500	Davis Mill Creek at Copperhill	5.16	345943	842256	1940-41, 1948-78, 1986
03563000	Ocoee River at Emf	524	350548	843207	1913
03564500	Ocoee River at Parksville	595	350548	843915	1911-16, 1921
03565500	Oostanaula Creek near Sanford	57.0	351939	844219	1954
03566000	Hiwassee River at Charleston	2,298	351716	844507	1898-1903, 1914-40, 1963
03566420	Wolftever Creek near Ooltewah	18.8	350343	840359	1964
03567500	South Chickamauga Creek nr Chickamauga	428	350051	851235	1928-78, 1980
03567900	Tennessee River at Citico Bar at Chattanooga	21,372	350319	861704	--
03568000	Tennessee River at Chattanooga	21,380	350512	851643	1874
03571000	Sequatchie River near Whitwell	402	351222	852948	1920
03584500	Elk River near Prospect	1,784	350139	865652	1904-08, 1919
03588000	Shoal Creek at Lawrenceburg	55.4	351440	872102	1932-34, 1967
03588500	Shoal Creek at Iron City	348	350127	873444	1925
03593005	Tennessee River at Pickwick Landing Dam	32,820	350354	881508	1975
03593500	Tennessee River at Savannah	33,140	351329	881526	1930
03598000	Duck River near Shelbyville	481	352849	862957	1934
03600088	Carters Creek at Butler Rd at Carters Creek	20.1	354302	865945	1986
03602500	Piney River at Vernon	193	355216	873005	1925
03603000	Duck River above Hurricane Mills	2,557	355548	874435	1925
03604000	Buffalo River near Flat Woods	447	352945	874958	1920
03604500	Buffalo River near Lobelville	707	354846	874751	1927

Active Recording Surface-Water Stations in Tennessee as of 2/29/88--Continued

Station No.	Name	Drainage area (mi^2)	Lat	Long	Date began
	OBION RIVER BASIN				
07026000	Obion River at Obion	1,852	361504	891133	1929-58, 1966
07026370	North Reelfoot Creek at State Hwy 22 nr Clayton	56.3	362750	891513	1980-83 1984
07026400	South Reelfoot Creek near Clayton	38.6	362620	891537	1984
07026640	Running Slough near Ledford, Ky.	10.8	363228	891859	1982-83, 1984
07026690	Reelfoot Lake near Phillipy	240	362759	892056	1984
07027000	Reelfoot Lake near Tiptonville	240	362109	892507	1940
07027010	Running Reelfoot Bayou near Owl City	247	361953	892402	1982-83, 1984
	HATCHIE RIVER BASIN				
07029500	Hatchie River at Bolivar	1,480	361631	885836	1929
07030100	Cane Creek at Ripley	33.9	354525	893305	1958-62, 1986
	LOOSAHATCHIE RIVER BASIN				
07030240	Loosahatchie River near Arlington	262	351837	893823	1969
070303573	Loosahatchie River at North Watkins Street, at Memphis	728	351515	900134	1986
	WOLF RIVER BASIN				
07031660	Wolf River at Walnut Grove Road, at Memphis	709	350758	895118	1986
07031694	Harrington Creek trib. at Elmore Park Road, at Bartlett	.33	351208	895126	1975
07031697	Harrington Creek trib. at Stage Road, at Bartlett	.91	351220	895305	1975
07031740	Wolf River at Hollywood St., at Memphis	788	351116	895832	1986
	NONCONNAH CREEK BASIN				
07032200	Nonconnah Creek near Germantown	68.2	350259	894908	1969
07032251	Nonconnah Creek at Rivergate Road, at Memphis	182	350432	900355	1986

APPENDIX 1--Continued

Active Crest-Stage Stations in Tennessee as of 2/29/88

[*, Operated as a continuous-record station]

Station No.	Name	Drainage area (mi^2)	Lat	Long	Date began
	CUMBERLAND RIVER BASIN				
03409000	White Oak Creek at Sunbright	13.5	361438	844014	1934, 1955-82, 1985
03418201	Doe Creek at Gainesboro	5.72	362123	853920	1978
03420360	Mud Creek tributary No. 2 near Summitville	2.28	353610	860133	1967
03420600	Owen Branch near Centertown	4.60	354230	855305	1955
03421200	Charles Creek near McMinnville	31.1	354300	854605	1955
03424900	Mulherrin Creek near Gordonsville	26.9	361128	855711	1982, 1986
03425045	Peyton Creek at Monoville	44.7	361837	855921	1986
03425357	Darwin Branch tributary at Hartsville	.66	362354	860908	1986
03425365	Second Creek near Walnut Grove	3.47	362401	861248	1986
03425500	Spring Creek near Lebanon	35.3	361049	861429	1955-61#, 1962
03425700	Spencer Creek near Lebanon	3.32	361420	862403	1955
03426874	Brawleys Fork below Bradyville	15.4	354444	861014	1983
034269424	Reed Creek near Bradyville	3.52	354444	861231	1983
03428043	Lytle Creek at Sanbyrne Drive at Murfreesboro	17.6	354938	862328	1978
03430400	Mill Creek at Nolensville	12.0	355732	864031	1965
03431000	Mill Creek near Antioch	64.0	360454	864050	1954-61#, 1962-63, 1964-75#, 1976
03431040	Sevenmile Creek at Blackman Road at Nolensville	12.2	360421	864400	1965
03431060	Mill Creek at Thompson Lane, near Woodbine	93.4	360704	864308	1965
03431120	West Fork Browns Creek at General Bates Drive, at Nashville	3.30	360629	864707	1965
03431240	East Fork Browns Creek at Baird-Ward Printing Company, at Nashville	1.58	360633	864600	1965
03431340	Browns Creek at Factory Street, at Nashville	13.2	360826	464531	1965
03431550	Earthman Fork at Whites Creek	6.29	361555	864951	1965
03431573	Ewing Creek at Richmond Hill Drive at Parkwood	2.17	361350	864628	1976
03431575	Ewing Creek at Brick Church Pike at Parkwood	3.02	361358	864654	1976
03431578	Ewing Creek at Gwynwood Drive near Jordonia	9.98	361358	864732	1976

APPENDIX 1--Continued

Active Crest-Stage Stations in Tennessee as of 2/29/88--Continued

Station No.	Name	Drainage area (mi^2)	Lat	Long	Date began
	CUMBERLAND RIVER BASIN--Continued				
03431581	Ewing Creek below Knight Road, near Bordeaux	13.3	361355	864814	1976
03431677	Sugartree Creek at YMCA Access Road, at Green Hills	1.51	360613	864912	1976
03431679	Sugartree Creek at Abbott Martin Road, at Green Hills	2.19	360623	864917	1976
03431795	Bednigo Branch trib. at Chestnut Grove	.47	362510	865411	1986
03432470	Murfrees Fork above Burwood	7.43	354858	865720	1986
03432925	Little Harpeth River at Granny White Pike, at Brentwood	22.0	360130	864909	1978
03434590	Jones Creek near Burns	13.3	360615	871905	1984
03434616	Hall Branch near Charlotte	.50	361148	872030	1984
034350021	Bartons Creek near Cumberland Furnace	22.29	361502	872000	1984
0343500213	Bartons Creek tributary near Stayton	.51	361519	871912	1984
03435030	Red River near Portland	15.1	363324	863414	1966-75, 1976
034351113	Honey Run Creek below Cross Plains	25.8	363231	864214	1986
03435930	Spring Creek tributary near Cedar Hill	1.40	363208	865926	1986
03436700	Yellow Creek near Shiloh	124	362055	873220	1957-80#, 1982
	TENNESSEE RIVER BASIN				
03461230	Caney Creek near Cosby	1.62	354703	831211	1967
03465607	Cherokee Creek near Embreeville	22.9	361224	822923	1984
03465780	Clear Fork near Fairview	10.5	361933	823347	1983
03466295	Camp Creek at Camp Creek	9.99	360539	824537	1983
03466865	Roaring Fork north of Greeneville	16.1	361245	825015	1983
03466890	Lick Creek near Albany	172	361454	825534	1984
03467480	Bent Creek at Taylor Gap	2.18	361408	830641	1986
03467992	Carter Branch near White Pine	4.25	360705	831855	1986
03467993	Cedar Creek near Valley Home	2.01	360803	831847	1986
03467998	Sinking Fork at White Pine	6.38	360721	831744	1986
03470215	Dumplin Creek at Mt. Hareb	3.65	360459	832551	1986
03476960	Indian Creek at Childress	6.79	362538	821554	1983
03478615	Evans Creek near Blountville	2.50	363119	821812	1983
03481600	Corn Creek at Mountain City	5.34	362923	814852	1959-61, 1963
03487507	Horse Creek at Sullivan Gardens	26.0	362813	823552	1983

APPENDIX 1--Continued

Active Crest-Stage Stations in Tennessee as of 2/29/88--Continued

Station No.	Name	Drainage area (mi^2)	Lat	Long	Date began
	TENNESSEE RIVER BASIN--Continued				
03490522	Forgey Creek at Zion Hill	0.86	362912	825308	1986
03491490	Dodson Creek tributary near Rogersville	.32	362119	825703	1983
03491540	Robertson Creek near Persia	14.6	362024	830227	1986
03494714	Dry Land Creek trib. near New Market	.20	360333	833413	1986
03494990	Flat Creek at Luttrell	22.4	361145	834444	1986
03519610	Baker Creek tributary near Binfield	2.10	354156	840246	1966-77, 1979
03519640	Baker Creek near Greenback	16.0	354021	864628	1965-75#, 1976
03527800	Big War Creek at Luther	22.3	362718	831429	1986
03528390	Crooked Creek near Maynardville	2.23	361556	835025	1986
03534000	Coal Creek at Lake City	24.5	361314	840927	1932-34#, 1955
03535180	Willow Fork near Halls Crossroads	3.23	360559	835427	1967
03555900	Coker Creek near Ironsburg	22.4	351305	842028	1983
03566599	North Chickamauga Creek at Greens Mill, near Hixson	99.5	351030	851340	1925, 1944, 1953-56, 1980
03569168	Stringers Branch at Leawood Drive, at Red Bank	1.54	350700	851728	1980
03571500	Little Sequatchie River at Sequatchie	116	350747	853510	1925, 1929-30, 1932-34#, 1944, 1951-54, 1965, 1979
03571730	Standifer Branch at Jasper	15.3	350422	853656	1982
03571800	Battle Creek near Monteagle	50.4	350803	854615	1955
03583200	Chicken Creek at McBurg	7.66	351103	864847	1955
03583300	Richland Creek near Cornersville	47.5	351910	865220	1962-68#, 1969
035944242	Owl Creek at Lexington	2.50	353826	882213	1984
03597300	Wartrace Creek above Bell Buckle	4.99	353745	862122	1966
03599200	East Rock Creek at Farmington	43.1	353005	864250	1954
03602170	West Piney River at Hwy 70 nr Dickson	2.16	360521	872812	1984
03604070	Coon Creek tributary near Hohenwald	.51	353407	874002	1967
03604080	Hugh Hollow Branch near Hohenwald	1.52	353459	874036	1967
03604090	Coon Creek above Chop Hollow, near Hohenwald	6.02	353519	874109	1967
03604580	Blue Creek near New Hope	13.2	360352	873858	1984
03604595	Little Blue Creek trib. near Gorman	.62	361944	874213	1984
03605880	Cane Creek at Stewart	4.12	361909	875021	1984
	OBION RIVER BASIN				
07024225	Neil Ditch near Henry	4.07	361019	882333	1984
07024370	Little Reedy Creek near Huntingdon	0.91	355544	882950	1984
07029090	Lewis Creek near Dyersburg	25.5	360314	892142	1955-78, 1980-83, 1985

APPENDIX 2

Active ground-water network in Tennessee as of 2/29/88

Station No.	Local well No.	Lat	Long	Date began
	RECORDER--60-MINUTE PUNCH INTERVAL			
361738082132900	Ct: H-1	361738	821329	1964
360835086441100	Dv:L-10	360835	864411	1985
350234085181200	Hm:G-36	350234	851812	1981
351428085003600	Hm:O-15	351428	850036	1975
360020087573300	Hs:H-1	360020	875733	1962
353839089493500	Ld:F-4	353839	894935	1966
354158089384300	Ld:G-12	354158	893843	1980
354357089271701	Ld:J-5	354357	892717	1982
354552089455900	Ld:L-2	354552	894559	1980
355251089350500	Ld:S-2	355251	893505	1980
352610087182401	Ln:R-014	352610	871824	1985
354223088380200	Md:N-1	354223	883802	1949
360543084343101	Mg:F-5	360543	843431	1984
360521085432601	Pm:C-1	360521	854326	1968
353922083345600	Sv:E-2	353922	833456	1979
350514089553700	Sh:K-75	350514	895537	1948
351435090005200	Sh:O-1	351435	900052	1940
350735089593300	Sh:P-76	350735	895933	1928
350900089482300	Sh:Q-1	350900	894823	1940
350958090173800	Ar:C-1	350958	901738	1983
350344090130000	Ar:H-2	350344	901300	1983
351349090062800	Ar:O-1	351349	900628	1983
	TAPE DOWN			
350503084505000	Br:E-1	350503	845050	1950-1955, 1964
354823086104400	Cn:D-1	354823	861044	1967
360200089280100	Dy:H-1	360200	892801	1955
360147089230700	Dy:H-7	360147	892307	1954
352226089330101	Fa:R-1	352226	893301	1949
352226089330102	Fa:R-2	352226	893301	1949
352112089571200	Sh:U-1	352112	895712	1946
352112089571300	Sh:U-2	352112	895713	1953
355505086541100	Wm:M-1	355505	865411	1950

APPENDIX 3

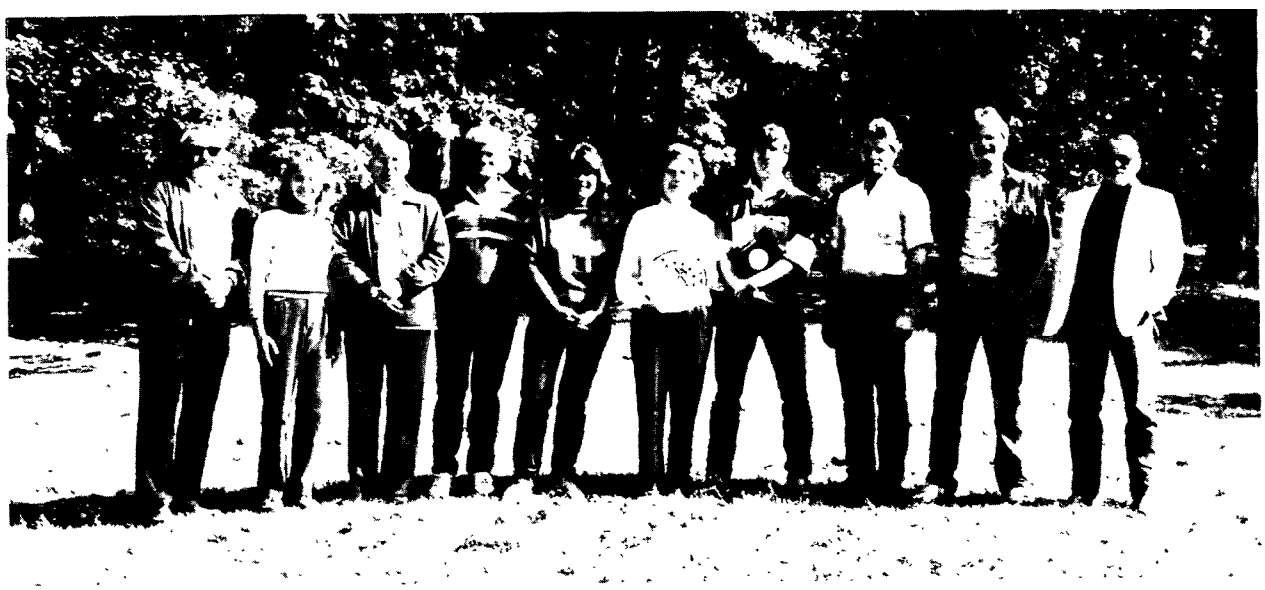
List of water-quality and suspended-sediment stations

[Q, chemical; B, bacteriological; S, sediment]

Station No.	Name	Drainage area (mi^2)	Lat	Long	Date began	Data type
	CUMBERLAND RIVER BASIN					
03418420	Cumberland River below Cordell Hull Dam	8,095	361712	855627	1980	Q
03425000	Cumberland River at Carthage	10,690	361453	855719	1975	Q,B,S
03426310	Cumberland River at Old Hickory Dam (Tailwater)	11,673			1979	Q
03427500	East Fork Stones River nr Lascassas	262	355506	862002	1975	Q
03428200	W Fork Stones River at Murfreesboro	177	355410	862548	1986	Q
03428500	West Fork Stones River near Smyrna	237	355625	862754	1965	Q
	TENNESSEE RIVER BASIN					
03495500	Holston River near Knoxville	3,747	360056	834954	1965, 1977	Q,B,S
03497300	Little River above Townsend	106	353952	834241	1964-82, 1986	Q,B,S
03535912	Clinch River at Melton Hill Dam	3,343	355307	841803	1973	Q,B,S
03593005	Tennessee River at Pickwick Landing Dam	32,820	350354	881508	1975	Q,B,S
03600085	Carters Creek at Petty Lane near Carters Creek	16.6	354340	865920	1986	Q,B,S
03600086	Carters Creek Trib near Carters Creek	2.94	354334	865920	1986	Q,B,S
03600088	Carters Creek at Butler Road at Carters Creek	20.1	354303	865945	1986	Q,B,S
03604000	Buffalo River near Flat Woods	447	352945	874958	1964	Q,B,S
	OBION RIVER BASIN					
07026000	Obion River at Obion	1,852	361504	891133	1975	Q,B,S
07026370	North Reelfoot Creek at State Hwy 22 nr Clayton	56.3	362750	891513	1980-83, 1984	S
07026507	Reelfoot Creek near Walnut Log Rd	113	362728	892999	1986	Q
07026695	Bayou DuChien near Walnut Log Rd	27.8	362809	892350	1986	Q
07027002	Reelfoot Lake Spillway near Tiptonville	240	362109	892539	1986	Q
	HATCHIE RIVER BASIN					
07029500	Hatchie River at Bolivar	1,480	361631	885836	1964, 1968, 1977	Q,B,S

INDEX

Knoxville Subdistrict personnel.



Memphis Subdistrict personnel.

Nashville Subdistrict personnel.

The USGS Tennessee District personnel.

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DEPARTMENT OF THE INTERIOR
U.S GEOLOGICAL SURVEY
A-413 Federal Building
Nashville, Tennessee 37203

POSTAGE AND FEES PAID
U.S DEPARTMENT OF THE INTERIOR
INT 413